

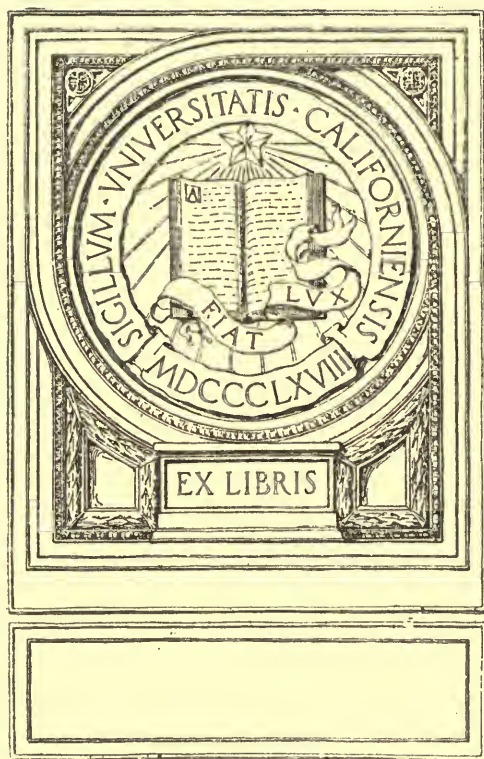
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MECHANICAL EQUIPMENT of SCHOOL BUILDINGS

Harold L. Alt



Mechanical Equipment of School Buildings

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Introductory Note

THE chapters of this book appeared originally as a serial in the *American School Board Journal* and the interest aroused among school board authorities and architects has led to the present republication in a more permanent form.

Schoolhouse design and construction have advanced remarkably during the past generation due largely to the intensive study of architects and engineers who have specialized in this branch of building and have developed a large body of well tested theory and practice. It has been the privilege of the author to share in this development as a designing and supervising engineer and more recently as a consultant of school boards and architects. The book is therefore the outgrowth of experience and wide observation of successful domestic engineering as applied to school buildings.

W. C. B.

Table of Contents

	Page
<i>Chapter I.</i>	
Heating and Ventilating—Business Organization in Schoolhouse Construction—General Principles of Heating and Ventilation—Types of Ventilating Systems—Location of Supply and Exhaust Openings in Classrooms.....	7
<i>Chapter II.</i>	
Ducts and Flues—Types of Duct Systems—Arrangement of Flues—Breathing Walls.....	13
<i>Chapter III.</i>	
Heating and Ventilating Special Rooms—Assembly Rooms—Down and Up Systems of Ventilation—Automatic Temperature Control.....	19
<i>Chapter IV.</i>	
Ventilating Toilets and Laboratories—Methods of Installing Toilet Exhaust Systems—Exhaust Systems for Chemical Laboratory Hoods—School Kitchen Ventilation..	25
<i>Chapter V.</i>	
Toilet Fixtures—Traps—Vitreous Ware Fixtures—Types of Closets—Ventilation of Fixtures—Flushing Devices.....	32
<i>Chapter VI.</i>	
Plumbing Fixtures—Flush Valves—Urinals—Ventilation of Urinals—Types of Bubbling Fountains—Sinks.....	37
<i>Chapter VII.</i>	
Number and Location of Fixtures—Basement Toilet Rooms—Types of Toilet Room Arrangement—Methods of Figuring Number of Fixtures—Special Arrangement of Toilet Rooms.....	43
<i>Chapter VIII.</i>	
Toilet Partitions and Shower Baths—Types of Partitions—Types of Shower Bath Stalls—Arrangement of Stalls—Metal Fittings.....	48
<i>Chapter IX.</i>	
Water Supply Systems—Types of Pncumatic Systems—Gravity Systems—Water Filters and Sterilizers—Pumps—Pressure.....	54
<i>Chapter X.</i>	
Hot Water Systems—Down Feed and Up Feed Systems—Methods of Heating Water—Control of Hot Water Systems—Mixing Valves—Forced Circulation.....	61
<i>Chapter XI.</i>	
Fire Protection—General Equipment—Sprinkler Systems—Standpipes—Fire Pumps—Hand Fire Extinguishers.....	68
<i>Chapter XII.</i>	
Drinking Water—Water Coolers—Refrigeration Systems—Ammonia Systems—Special Drinking Fountains.....	73

	Page
<i>Chapter XIII.</i>	
Sewage Disposal—Septic Tank Systems—Operation and Arrangement of Septic Tanks— Disposal Fields.....	78
<i>Chapter XIV.</i>	
The School Power Plant—Economy of the School Power Plant—Typical Arrangement of Plant—Boilers and Engines—Electric Current.....	84
<i>Chapter XV.</i>	
The School Swimming Pool—General Considerations—Cleanliness—Filters and Sterilizers— Arrangement of Pools—Waterproofing.....	90
<i>Chapter XVI.</i>	
Pool Equipment—Water Heaters—Circulation Pumps—Filters—Electric Sterilizers— Rules for Operating Pools.....	95
<i>Chapter XVII.</i>	
Electric Lighting—The Need of Illuminating Systems—Types of Lighting—Types of Fix- tures—Standards of Light Intensity—Location of Lighting Outlets—Illumination of Special Rooms.....	99
<i>Chapter XVIII.</i>	
Vacuum Cleaning—High and Low Vacuum Systems—Floor Outlets—Arrangement of Piping—Special Pipe Fittings—Types of Vacuum Cleaning Machines.....	104



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Mechanical Equipment of School Buildings

CHAPTER I

Heating and Ventilation

The school laws of every state in the Union make the erection and maintenance of proper schoolhouses the *first* and one of the most important duties of school boards. The laws recognize tacitly that while the schoolhouses are only a physical accessory to the education of future citizens, it is nevertheless true, that neither children nor teachers can perform their respective part in the educational process unless the schoolhouses are convenient, sanitary, safe and comfortable.

To school-board members and citizens individually, the educational aspect of erecting and equipping schoolhouses may not appear as an intimate duty so much as the more vexing duty of securing funds and of using those funds to the best advantage. The pecuniary problems in turn are not less troublesome to members of school boards than the actual architectural and engineering problems, bound up as they are with the educational demands of teachers and superintendents, the hygienic requirements of sanitarians and the limitations of knowledge and experience on the part of the members themselves.

Several millions of dollars of the taxpayers' money are spent every year on new buildings, and whether this vast amount is spent wisely or unwisely is dependent, almost entirely, on the wisdom and care of the school boards. Considering the fact that comparatively few members ever have previous experience in construction work of any kind beyond, perhaps, the erection of their own homes, it is remarkable that the various communities thruout the country are not loaded up with a large number of well-meant, but absolutely unfit, school buildings. That this is not so is due, without doubt, to the painstaking attention given by the average board in handling building problems. Still, even *care* cannot produce the results obtained by *experience*.

It is the purpose of this and succeeding chapters to present to school-board members, both individually and collectively, the various problems arising in almost every new schoolhouse which is erected and to discuss these problems *with*

their solutions in a simple, plain and straightforward manner easily appreciated by the uninitiated.

It is not desired to enter into the discussion of the arrangement or construction of school buildings so much in this book as it is to discuss the equipment and mechanical end. The architectural end should be left to the architect selected by the board with the school board acting as an advisory and criticising committee. The school board which tries to undertake the erection of a school building without an architect is not only going to get into a lot of difficulties but will end up by wasting the public money.

Yet the employing of an architect will not necessarily solve all the problems. The modern school has developed into such a distinctive type of building that problems ordinarily solved by standard methods in other structures require totally different treatment for school use. The boards thruout the country should employ not only competent architects but should assist the architects after they are employed by turning over the responsibility of the mechanical equipment to engineers, thoroly experienced in such work. "The best is the cheapest" in the long run and the best engineer is the one whose *experience* on schools has been the largest and most successful. No school board can go wrong in following this procedure and the larger the building the greater the emphasis which must be laid on this point.

Even then, the boards should be familiar with the various points involved as in almost every instance they make the final decision as to the results justifying the expenditure and unless they know what the results will be and the value of such results there is great chance of financial waste.

In Fig. 1 is shown the normal business organization of school construction and one which gives the most satisfactory results. Here the school community appoints the school board which in turn selects the site and the architect and engineer. The site (according to the safe bearing load of the soil) determines the foun-

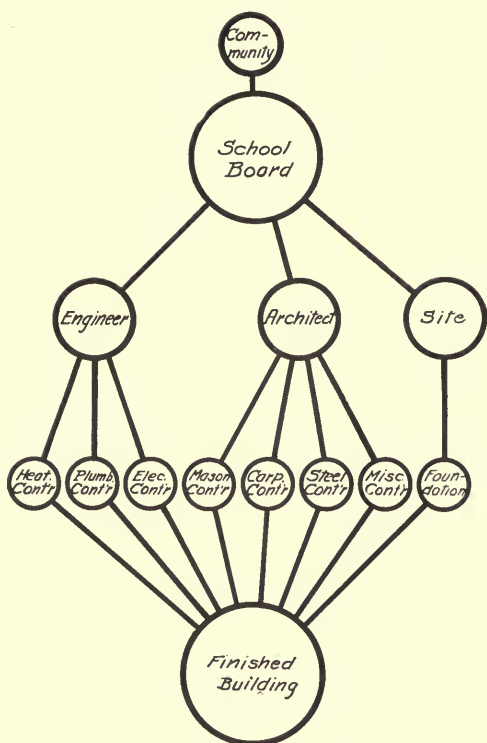


Fig. 1. BUSINESS ORGANIZATION IN SCHOOLHOUSE CONSTRUCTION.

dation and the architect must not be held responsible for expensive foundations necessitated by poor bearing soil. All school boards should take borings to determine the character of the under strata before purchasing as the necessity of expensive foundations will often make a higher priced site really cheaper.

After the contracts are let the engineer controls the heating, plumbing and lighting contractors' work, while the masonry, carpentry, steel, painting, plastering, roofing and miscellaneous work is under the control of the architect. The work of these contractors is united to form a finished and complete building, and all disputes are carried back thru the architect or engineer to the school board for judgment. It is better that the engineer be selected and appointed by the board as he is then better able to serve the board's interest alone than when he is selected by the architect and is therefore under obligations to him. It goes without saying, however, that the selection of an engineer who is antagonistic to the architect is not good business policy since they must co-operate.

Let us take first the matter of heating and

ventilation since this is the most important of all the mechanical contracts amounting from ten to fifteen per cent of the total cost of the building. Of course, the problem of ventilation consists of supplying a reasonable and proper amount of fresh and warmed air to each classroom and other occupied rooms in such a way as to least inconvenience the occupants and so as to produce the most beneficial results. After this air has been breathed or otherwise contaminated the logical continuation of the problem consists of the removal of such foul air from the locations where it naturally collects, thus maintaining a circulation in the atmosphere.

Before the subject of ventilation can be intelligently considered the composition of the atmosphere must be noted, together with the changes produced which render it unfit for further use.

In the first place, air is a mixture of gases being normally about one part nitrogen and four parts oxygen with some ozone and carbonic acid gas; besides this there are usually present small quantities of ammonia, sulphuric and nitric acid, floating organisms and inorganic matter, together with various local impurities.

The oxygen is by far the most important of the various gases, it being the gas required both in combustion and respiration. The nitrogen serves as a diluent of the oxygen and does not enter actively into any of the processes in which we are interested.

Carbonic acid gas, while in itself not especially harmful, is a sort of gauge on the purity of the air. This is owing to the fact that, while in the open country the proportion of this gas

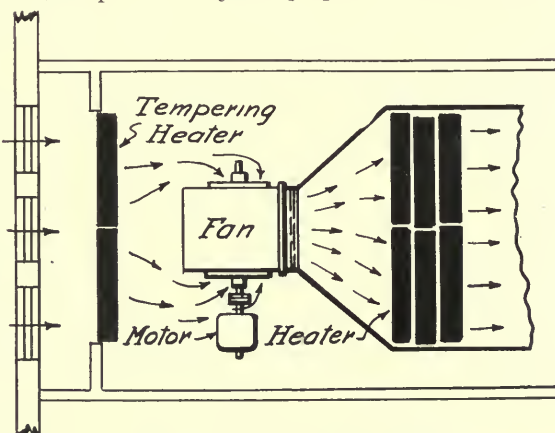


Fig. 2. PLAIN FAN APPARATUS.

is only 3 to 5 parts in 10,000, in the process of respiration its proportion is increased in almost direct ratio with other more harmful, but less easily detected, impurities. Therefore, the proportion of carbonic acid gas is almost an invariable indication of the degree of foulness reached by the air.

It is a generally accepted standard that not less than 30 cubic feet of fresh air per minute

This much being decided upon, the board must next decide if the air is to be supplied exactly as it comes from the outside—dust laden, smoky or odorous as it often is — or whether money shall be spent for a filter or air washer.

In Fig. 2 a ventilating apparatus, or “fan room arrangement” as it is often termed, is shown in which no modification of the air is

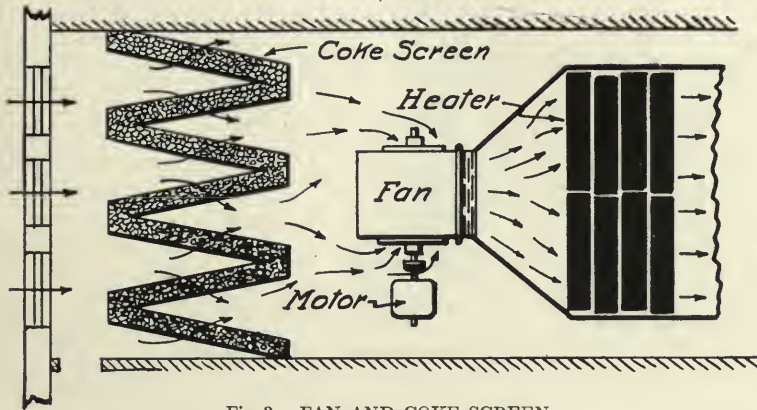


Fig. 3. FAN AND COKE SCREEN.

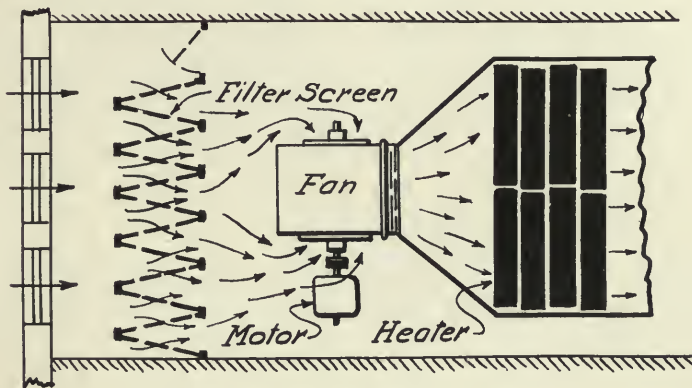


Fig. 4. FILTER SCREEN AND FAN.

should be supplied for each pupil in a classroom—in fact, this is required by law in some states. Another authority gives 50 cubic feet per minute for high schools and 40 cubic feet per minute in grammar schools. It is not just apparent why the high school student who generally is in the building for a shorter period, should be thus favored. From practical experience and general practice no school board will go wrong, or can even be subject to criticism, in adopting the 20 cubic foot standard.

made beyond that of raising its temperature slightly by the “tempering heater.” Then it goes to the “fan” and is pumped thru the “heater,” which warms it, into ducts to the classrooms. In Fig. 3 a coke screen is shown, this consisting of vertical wire mesh partitions 12 in. or 18 in. apart, between which coke is placed and the air drawn thru the mass. The filtration obtained by this method is not particularly effective and the process of cleaning the filter is difficult.

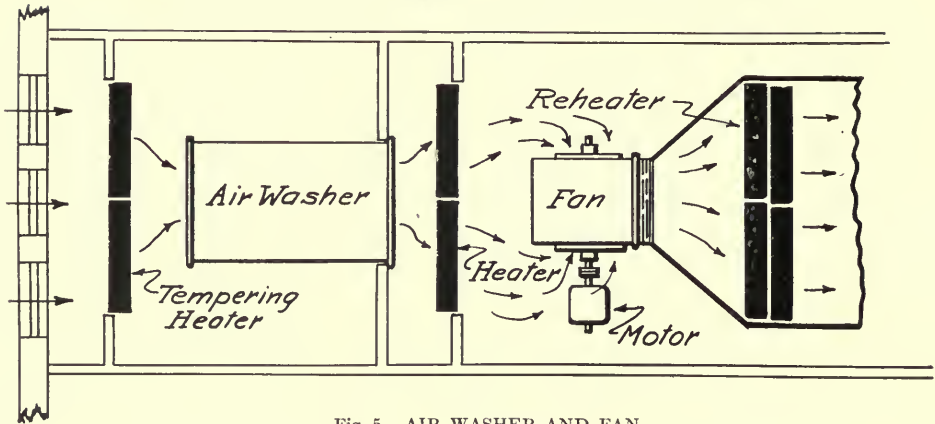


Fig. 5. AIR WASHER AND FAN.

In Fig. 4 a cloth filter is shown which consists of a large number of frames, across which cheese cloth is stretched as a massive strainer and thru which the air is drawn before being sent to the rooms. The filter will not do anything beyond catching the larger dust particles, etc., which would otherwise be carried along with the air, but it is easier to clean and preferable to the coke filter.

Fig. 5 shows an "air washer" which is a device for washing the air by means of a fine water spray that removes not only dust but also a large proportion of smoke and odors which at times may be carried in from the outside. Besides this, the air washer can be procured with a regulating device which maintains the humidity or moisture in the air at any desired degree, doing away with the excessively dry and parching steam heat effects ordinarily experienced. By all means install an air washer unless financial limitations absolutely prohibit its use. Fig. 6 shows an elevation of Fig. 5 giving an idea of the appearance of the apparatus when properly set on foundations.

In order to properly introduce the fresh air into a schoolroom and also to withdraw the foul air, the location of the supply and exhaust openings must be carefully determined. Of course, the main object is to circulate *all* the air in the room, or to put it another way, to circulate air in all portions of the room, while a secondary object is to circulate the air in such a manner as not to make air currents disagreeable or even perceptible.

Let us take Fig. 7 which shows the plan of a typical small room with the approximate circulation of air indicated by arrows between the supply and exhaust registers—which are located fairly close together. It will be seen that owing to the narrowness of the room this arrangement is fairly good but entirely out of place when a room is of greater width, as shown in Fig. 8, where fully two-thirds of the room is stagnant.

In Fig. 9 is shown the normal method of treating standard sized classrooms for say 40 or 50 pupils. It will be readily seen that the amount of stagnant area is comparatively small. The diagrams hold reasonably true regardless of

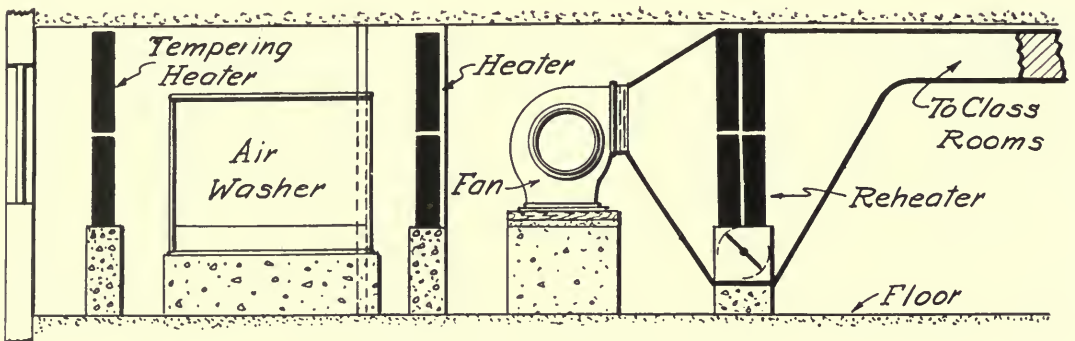


Fig. 6. SIDE VIEW OF AIR WASHER AND FAN.

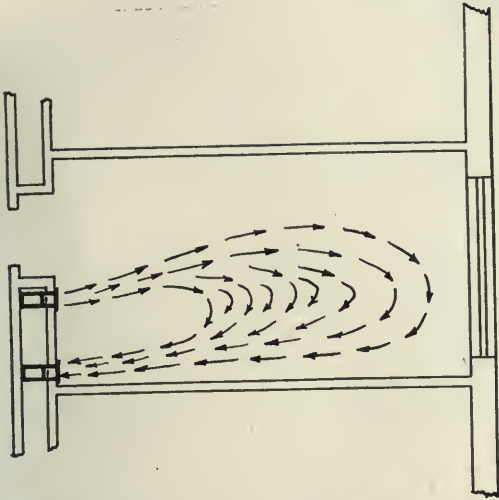


Fig. 7. Plan of schoolroom showing effect of locating supply and exhaust openings near one corner of narrow room.

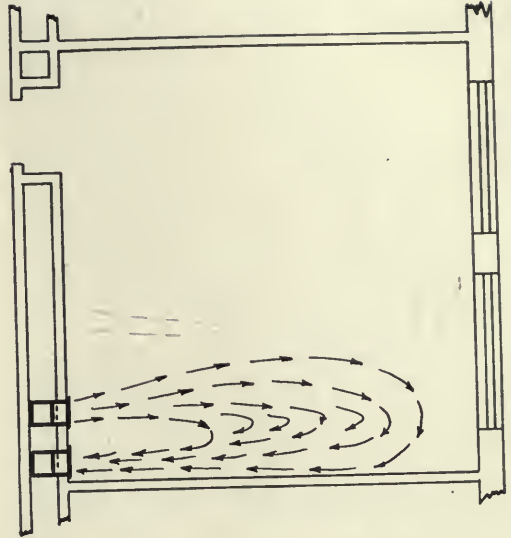


Fig. 8. Plan of schoolroom showing effect of locating supply and exhaust openings near one corner of large, square room.

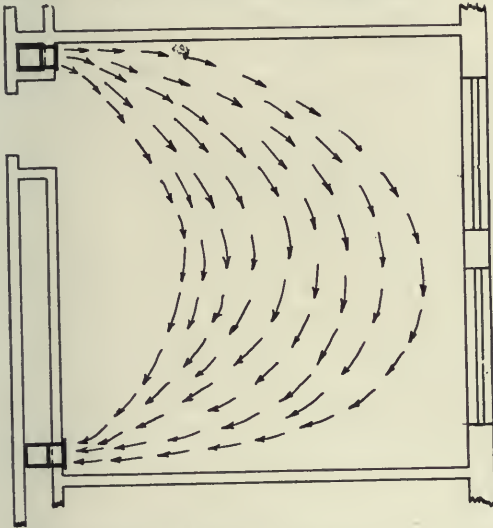


Fig. 9. Plan of schoolroom showing effect of locating supply and exhaust openings at inner corners.

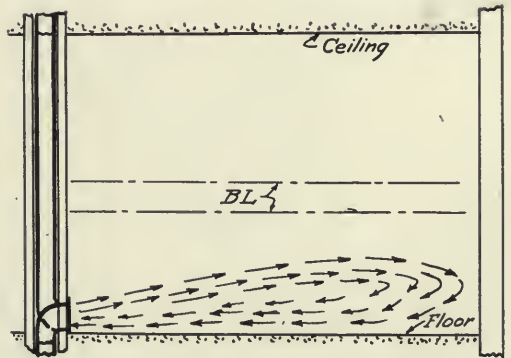


Fig. 10. Section of classroom showing effect of locating both supply and exhaust openings at floor line.

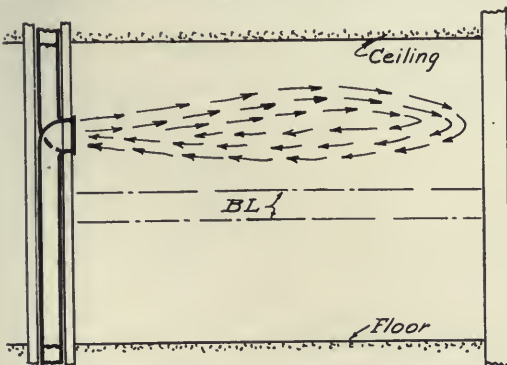


Fig. 11. Section of classroom showing effect of locating both supply and exhaust openings above breathing line.

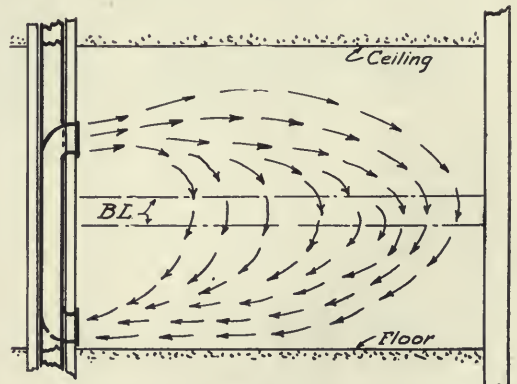


Fig. 12. Section of classroom showing effect of locating supply opening above breathing line and exhaust opening at floor line.

the height of the openings above the floor, but the exact motion of the air is affected by the movement of the occupants, the opening and closing of doors, the shape of the inlet and the velocity of the entering air.

In Fig. 10 is shown a typical room in elevation with both the supply and exhaust openings at the floor. It will be seen that with such an arrangement the circulation is likely never to reach the "breathing line," BL, which is the approximate level from which the air is drawn into the lungs. In Fig. 11 a similar effect is shown with both openings located about 8 ft. 0 in. above the floor.

Fig. 12 shows the circulation with the supply register 8 ft. 0 in. above the floor and the vent outlet at the floor. It can readily be appreciated that this is the best method for circulating verti-

cally across the breathing line, and is known as "downward ventilation" since the general movement of the air is in this direction. The reversing of the supply and exhaust openings would result in a similar effect but in an upward direction being known as "upward ventilation." This is seldom used, however, (owing to draughts produced at the floor) except in auditoriums. The arrangement shown in Fig. 11 is the regular standard generally adopted.

A combination of Fig. 9 and Fig. 11 produces the best all-around results; that is, the supply inlet should be at one end of the rooms about 8 ft. 0. in. above the floor to avoid draughts below the head line, and the vent outlet should be at the other end of the room close to the floor. No draught, of course, is ever felt in front of a vent outlet.



A TYPICAL CLASSROOM.

CHAPTER II

Ducts and Flues

After the manner of treating the air at its intake and the method of introducing it into the rooms have been decided, there still remains the matter of conveying the air from the fan room to the classrooms and of disposing of the foul air which is withdrawn at the exhaust registers—in other words the duct system.

In connection with fan operated ventilation systems there are three general distribution methods in use. These are known as the "trunk line" or single duct system, the "double duct" or hot-and-cold-air system and the "individual duct" or separate duct system. The differences between these three methods are readily perceived by reference to the figures accompanying this chapter.

In Fig. 13 is shown a plan view of a trunk line system in which the main duct is run on the basement corridor ceiling and supplies risers to the various rooms, these risers being concealed in a double wall (called a "breathing wall") from the first floor up.

In Fig. 14 is shown an elevation of this system which makes clear the manner of temperature regulation of the air and also the limitations of such regulation. The air is assumed in this case to have already passed thru a tempering heater which raises the temperature to a little above freezing point before it enters the fan. It is then discharged by the fan both directly thru the heater and also under the heater by means of the bypass shown. The air passing below the heater is, of course, unaffected by the heater while the air passing thru

the heater has its temperature raised to a rather high degree.

The air furnished the classrooms is a mixture of these two hot and cold currents of air which is controlled by the damper in the bypass under the heater which produces a combined tempered air supply—all the tempered air, however, being of the same temperature and delivered to the classrooms thru the flues and outlets indicated.

This system, while the cheapest to install, has its chief drawback in the fact that a classroom on the north side of the building will be supplied with air at exactly the same temperature as one on the south side. Similarly, a room on the windy side and a room on the sheltered or lee side will receive exactly the same service. This is radically wrong as the rooms will require air of temperature at considerable variance to maintain the proper 68 or 70 degrees Fahr. in each.

It is often necessary or cheaper to connect the bottom of the vertical flues with a duct run near the base and then to unite the ducts at the fan room. A plan of this kind is shown in Fig. 15. This splitting up of the main duct does not alter the character of the system, as a trunk line system, since this type may be defined as a system which supplies all the flues (vertical risers) from a main duct or branch, the air being all of the same warmth as its temperature is determined in the fan room. Of course, a trunk line may have auxiliary heaters placed in the base of several flues which will

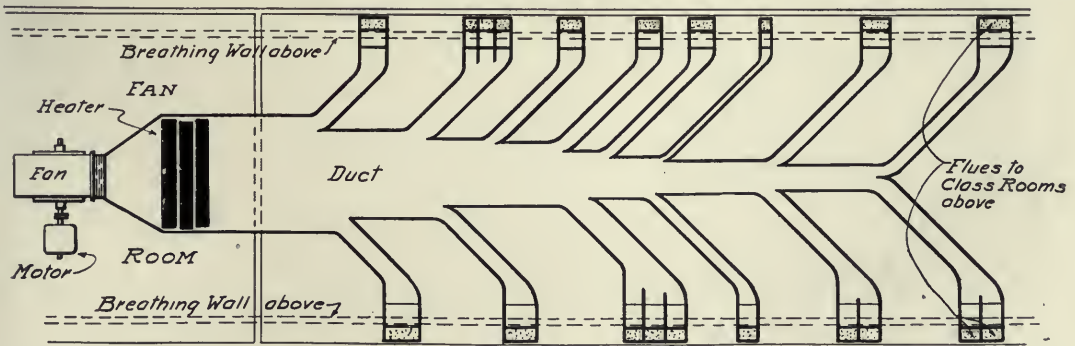


Figure 13.

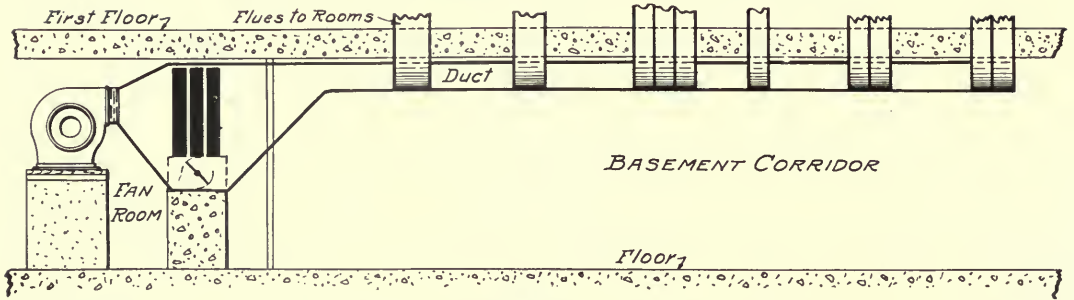


Fig. 14.

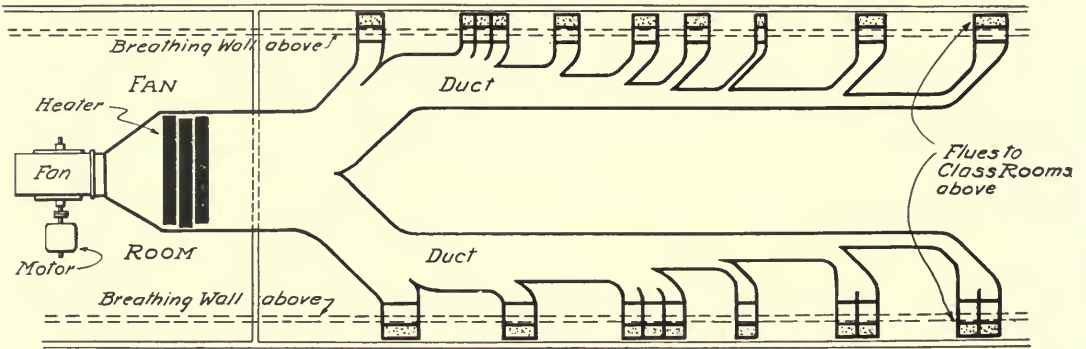


Fig. 15.

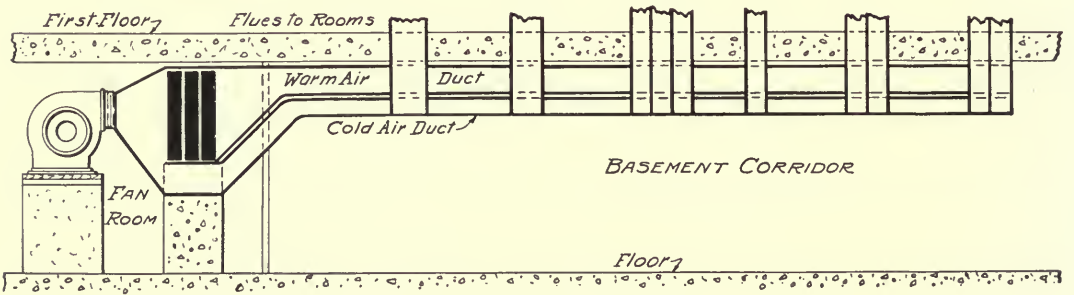


Fig. 16.

vary the temperature in the individual flue, but, in general, the above definition holds.

The double duct system really consists of two trunk lines, one above the other, in plan view appearing the same as the ordinary trunk lines shown in Figs. 13 and 15. In elevation, however, as shown in Fig. 16, there is a radical difference.

The air is blown partially thru the heater and partially thru the bypass under the heater. There is no damper in the bypass so that the air passing below the heater enters the lower duct unhampered while the air passing thru the heater enters the upper duct, which has to

be made large enough to supply *all* the air necessary in extremely cold weather. Any modification of this hot air, which it is desired to obtain in milder weather, or for protected rooms, is procured by the use of mixing dampers located at the base of each flue, these dampers being arranged to gradually cut off the warm air sup-

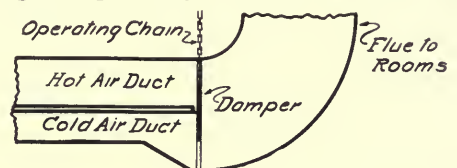


Fig. 17.

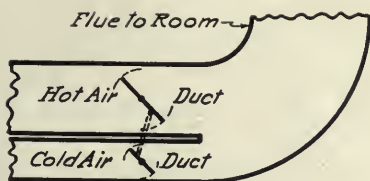


Fig. 18.

ply and open up the cold air inlet from the lower duct. Typical arrangements of this kind are shown in Figs. 17 and 18.

vital consideration as it may require the dropping of the whole basement floor level a foot or more in order to obtain proper headroom.

To obviate the disadvantages of the trunk line and double duct systems the individual duct system has been devised. So far as piping goes, this system resembles the common hot-air furnace, each flue or room having an individual supply duct carried back to the heater. (Fig. 19.)

The temperature of the air in this system is

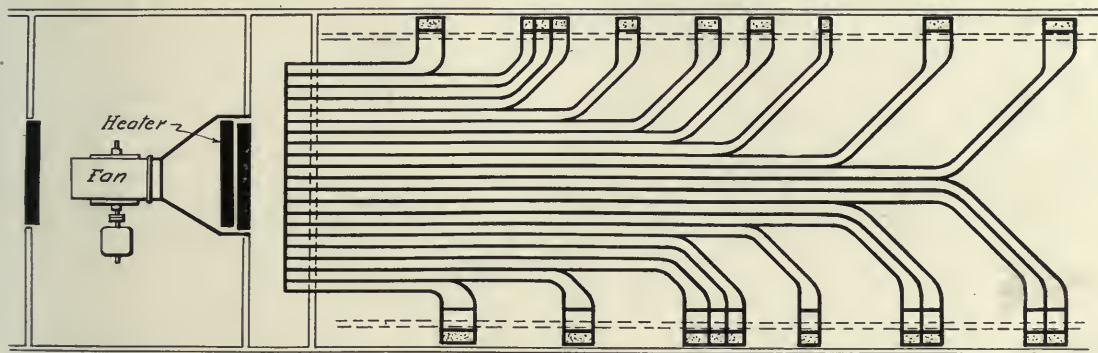


Fig. 19.

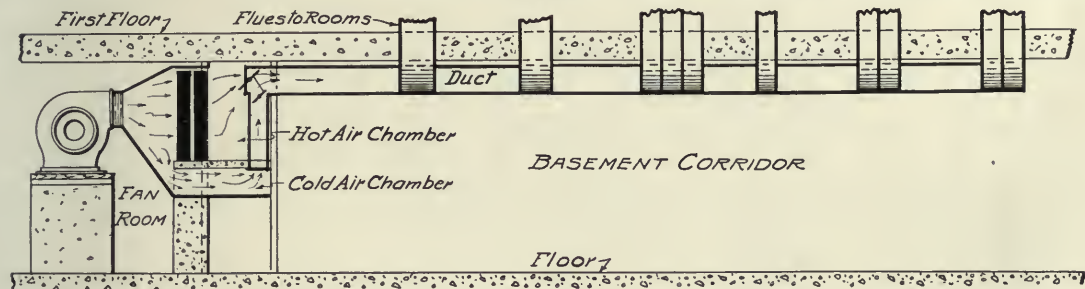


Fig. 20

The air in the lower duct is usually at a temperature of 35 to 40 degrees Fahr. in extreme cold weather, as in this case also *all* air is previously drawn thru a tempering heater. When the outside temperature rises above 35 to 40 degrees the tempering heater is shut off and the temperature of the air in the lower duct is then the same as the outside air. The cold air duct is usually made from 50 to 66 2-3 per cent of the size of the hot air duct.

It can be seen that the double duct system renders possible the control of the temperature of the air to each room by the use of the mixing dampers but the headroom in the basement is cut down by a little *more* than the exact height of the second duct. This is often a most

regulated at the heater (as in a trunk line system) but is governed by the double damper arrangement (similar to that in a double duct

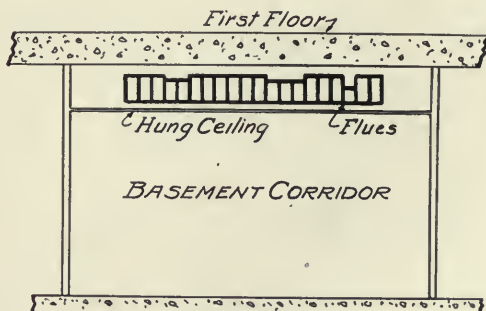


Fig. 21.

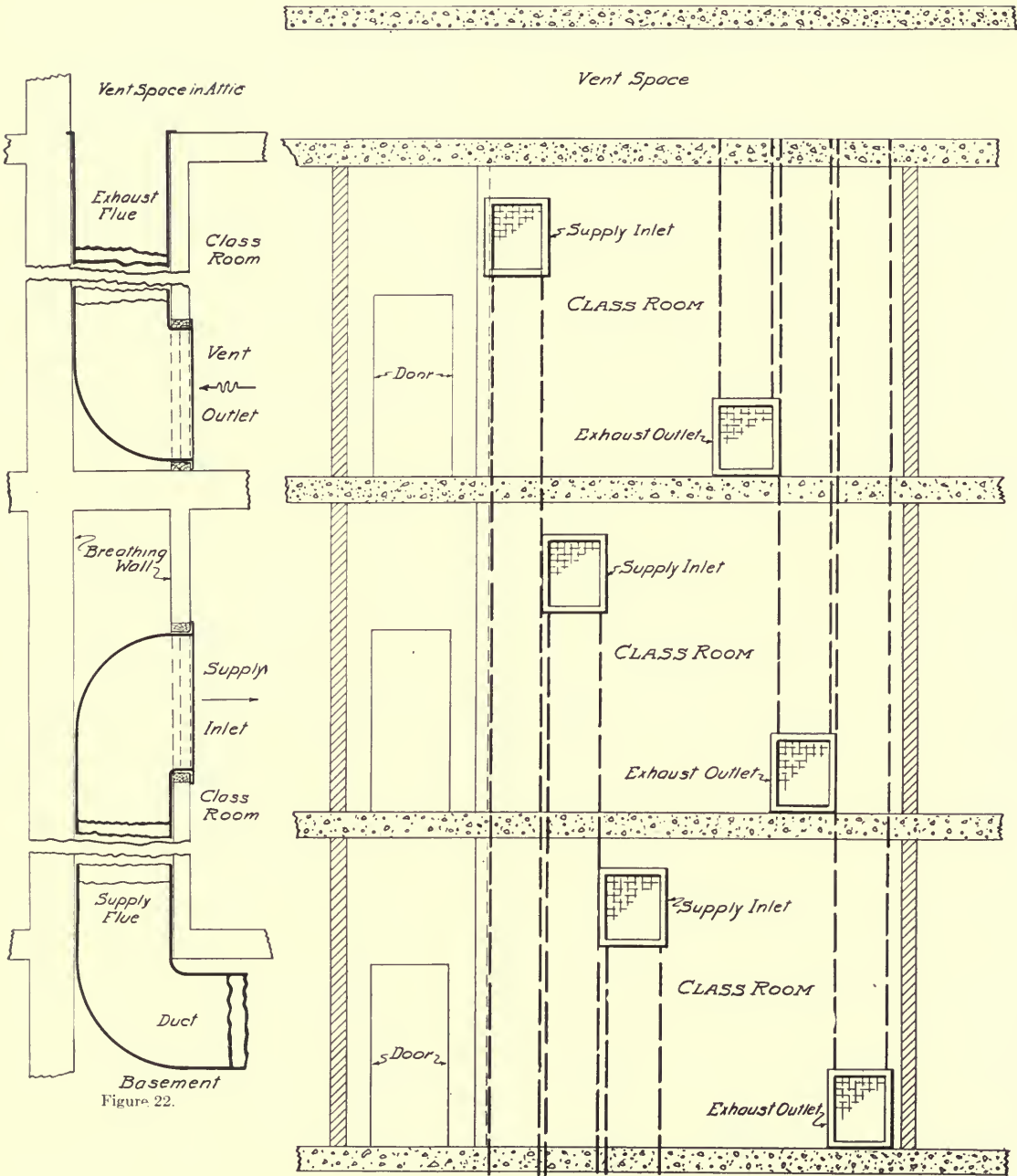


Figure 23.

system) indicated in the elevation of this system (Fig. 20), this being done *separately*, however, for each and every duct.

This arrangement permits each and every classroom to receive air at its own required

temperature regardless and independent of every other room in the building. The mixing dampers are controlled by thermostats in the various rooms which throw the dampers automatically and maintain (if the room radiators

are similarly controlled) a temperature varying not to exceed three degrees.

Since classrooms for a given school in general seat about the same number of pupils, it follows that most of the flues will be a certain standard size and only those of larger or smaller rooms will be of odd size. This fact makes possible the compact arrangement on the basement ceiling indicated in the cross section of the basement corridor shown in Fig. 21.

It would seem at first that the cost of an individual duct system would greatly exceed that of a trunk line or double duct system, but such has not proved to be the case in practice. This system can be designed so that the difference in cost on a heating contract involving, say, \$10,000.00 to \$20,000.00 would not exceed \$300.00 to \$800.00 according to the design. This is owing largely to the fact that the smaller ducts can be constructed of lighter gauge metal, do not require bracing like the larger trunk lines,

Certain advantages are secured in the arrangement of flues in the breathing walls to supply fresh air from the basement and exhaust foul air from the attic. One of these is the saving of space in the breathing wall which is often very crowded owing to numerous openings for doors, chutes, pipe shafts, etc. As shown in Fig. 22 (which is a cross section of a typical breathing wall) the space used for a supply flue going to the first floor could be utilized for an exhaust flue from the second or third floor to the attic, while a supply flue stopping at the second floor could be used as an exhaust space for a third floor exhaust flue. If both the supply and exhaust were carried to the basement this would of course be impossible and would overcrowd the breathing wall at the lower floors with just double the number of flues.

An elevation of three typical classrooms one above the other is shown in Fig. 23 with the

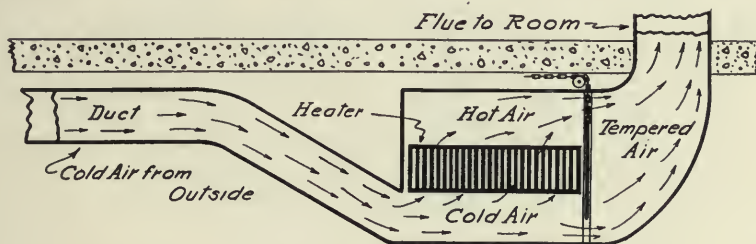


Fig. 24.

and can, to a great extent, be built in the shop where all facilities for quick completion are at hand.

This system is at present being installed in the Bridgeport, Conn., High School, in the Montclair, N. J., High School, the Schenley High School of Pittsburgh, and many others; no school board should allow any other to be used unless forced by financial limitations.

Flues are vertical air pipes run usually in the breathing walls so as to be concealed. In almost all cases the warm, fresh-air flues come from the basement and the vent flues go to exhaust fans in the attic. A few schools are arranged to have both the supply and exhaust flues run to the basement. None are arranged with the supply flues run to the attic as this necessitates carrying the large steam pipes for the heaters from the boilers (which are always in the lowest portion of the building) up to the attic level and also places the heaters where they are not accessible for the engineer.

customary flue runs and outlets. Of course a slight advantage in air circulation would be obtained if the supply outlets could be located close to the left hand wall similar to the location of the vent outlets at the other side. This is a manifest impossibility unless the door to the room is thrown practically into the center of the wall which is generally out of the question.

In the vent space above the classrooms are placed discharge fans which draw the air out of the vent space and discharge it into the outer air where it is dissipated.

Oftentimes cases are met with where the amount of money available or appropriated for a school building does not nearly cover the work involved so that rigid cutting of many desirable features is imperative. In such cases the tendency is to turn toward what is known as gravity heating. The writer of these articles does not feel justified in advocating this system which consists of bringing in a cold air supply

to a heater set near the base of the flue, as detailed in Fig. 24, the hot air rising in the flue by expansion, after being heated.

The sliding damper on the chain is one method of controlling the air temperature in the flue, the rising of the damper cutting off the hot air coming from the heater and at the same time opening up the cold air bypass under the heater. Thus the tempered air in the flue can be graduated to any desired degree within reasonable limits. Of course, the operation of this system depends entirely on the tendency of warm air to rise, and therefore the circulation is better in extremely cold weather than at any

other time. Such a system, altho producing fair results at times, is dependent too much on outside weather conditions. It is never possible to say that any certain amount of air per pupil, is introduced into a room as the amount constantly varies with the wind and outside temperature. It is not impossible to even have a strong wind reverse the air flow in a classroom from its supply register into an exhaust, driving all the bad air in the room back into the fresh air duct and thence into some other classroom. More than this the gravity system lacks sufficient motive power to allow the use of air filters or even air washers.



A TYPICAL HIGH SCHOOL AUDITORIUM. SCHENLEY HIGH SCHOOL, PITTSBURGH, PA.

CHAPTER III

Heating and Ventilating Special Rooms

The first step in the transition which occurs in schoolhouses between the common classroom and the auditorium, is the enlarged classroom or, as it is generally termed, "study room". This is often obtained by simply omitting the partition between two of the common classrooms thus making the study room of approximately twice the size of the ordinary room. Since the study room will then be of the same width but twice the length of the regular classroom, it may be ventilated in the same manner so long as the distance is not increased between the registers and the outside wall. The increase in length is taken care of by installing double the number of registers in order to obtain good distribution of air—for instance, two supply registers (or, one of twice the normal size) might be placed in the wall about the middle of the room and an exhaust outlet at each end. This arrangement can also be reversed, if desired, and a supply register placed at each end of the room with a double exhaust outlet in the middle.

The next step toward the auditorium is the "assembly room" or "school hall" which is usually larger than a study room and is generally equipped with a platform or small stage. The width of the assembly room is often greater than the study room so that registers on one side of the room are not sufficient to throw the air across and properly supply the farther side of the room. For this reason supply and exhaust registers are generally placed on both sides of the room. Where a stage or platform is installed the registers should be changed somewhat to accommodate the occupants of the platform and also to take care of the low portion of the hall, this being especially important if the floor is inclined so as to form a pocket in front of the stage. In this case wall supply registers should be located eight feet, or so, above the stage level and a large portion of the exhaust should be taken out from registers located in the vertical front of the stage and at the lowest part of the floor level. In fact, the entire front of many stages and platforms is turned into a continuous line of registers, the balance of the exhaust air being drawn off by

other registers located at the floor level in the middle and rear of the hall.

Since halls and study rooms are usually of one, or, at the most, one-and-a-half story height, they should be supplied with the same amount of air per minute per pupil as the ordinary classroom. With an auditorium running up two, three, or even four stories high the large amount of air contained will usually help out to a considerable extent the amount required for ventilation so that unless the auditorium is intended to be continuously occupied for three or four hour periods a supply of 20 cubic feet per minute per occupant is sufficient; but for long period use the supply should not be less than the standard thirty cubic feet.

It is impossible to go into the proper means of ventilating the auditorium in all phases of its development in a book of this size but to show the progress being made in this line it is desired to call attention to a high school recently under construction, the auditorium of which is shown at successive levels in Figs. 25 to 29 inclusive. This school has cost about \$750,000, and has probably the most carefully ventilated auditorium of any school in the country. In the plan shown in Fig. 25 is given a view of the vent space under the floor of the auditorium (this space being seven or eight feet high) and underneath which is located an apparatus room with the fans, air washers, heating coils, motors, etc. The air is supplied by a fan situated in the apparatus room which discharges into the large duct marked "from supply fan" and the air is exhausted thru the other large duct marked "to exhaust fan". The bad air is gotten rid of by the exhaust fan discharging it into the duct marked "discharge" which leads to the outer air.

In the main floor plan (Fig. 26) are shown a large number of small black circles, these being floor openings with mushrooms so as to connect the floor with the vent space below at every other seat, while under the balcony registers are placed in the gallery ceiling as shown in dotted lines.

A plan is shown in Fig. 27 of the vent space

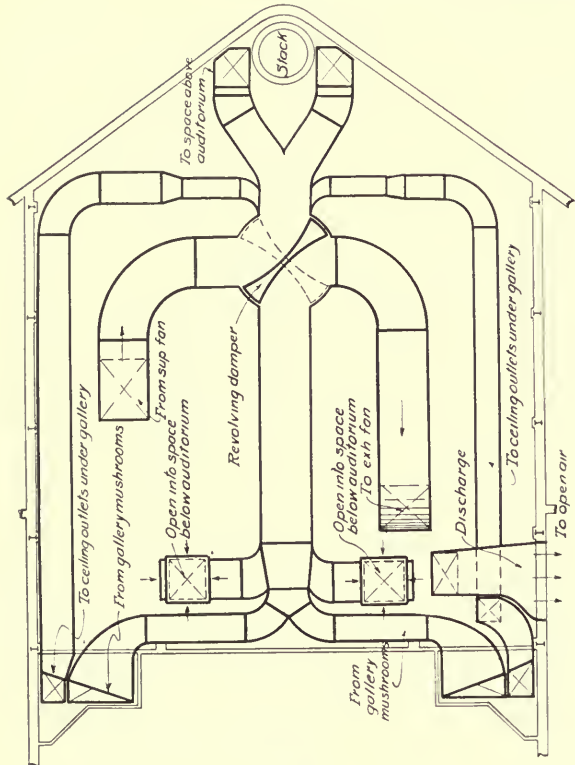


Fig. 25.

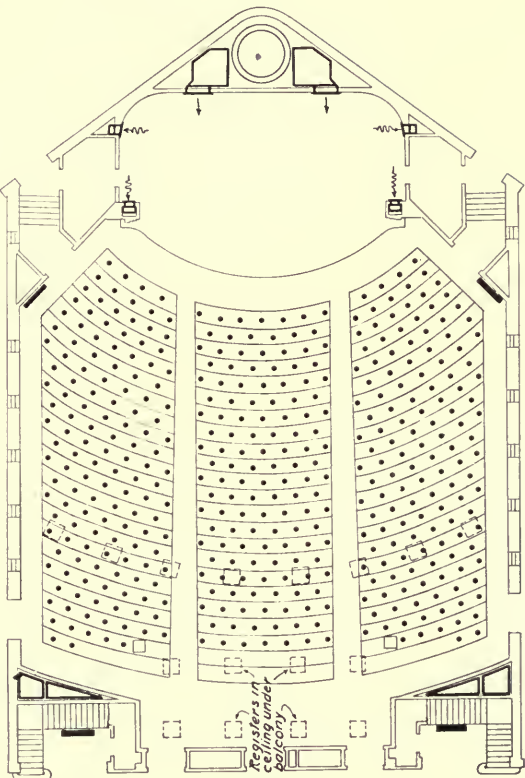


Fig. 26.

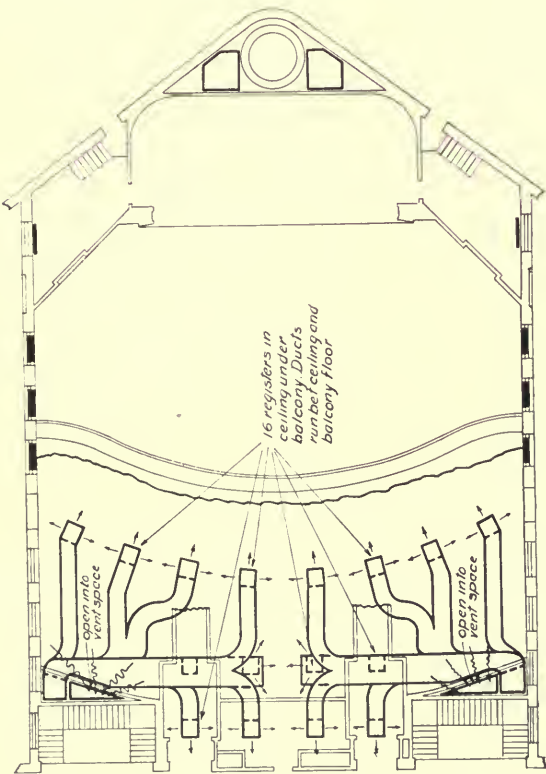


Fig. 27.

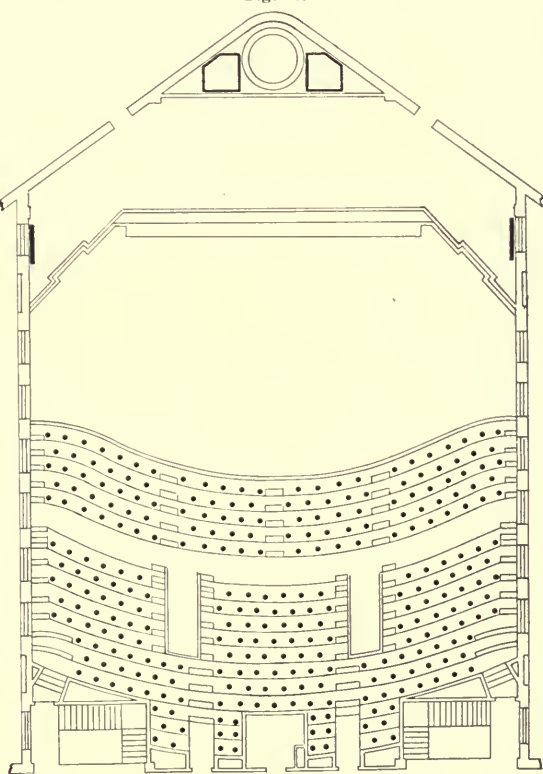


Fig. 28.

in the balcony with the balcony floor removed and the ducts connecting to the registers in the ceiling under the balcony indicated. In Fig. 28 is shown a plan of the balcony with the mushroom inlets the same as the ground floor. Fig. 29 gives the vent space above the auditorium ceiling and shows the connections to the ventilating girdle a cross section of which is given in Fig. 30. This girdle allows air to enter the auditorium all around its entire length and also serves to conceal a row of electric lights for indirect illumination.

The pipe coils shown in Fig. 29 are for the purpose of keeping the roof slab warm over the auditorium as experience has proven that where the air is properly humidified the presence of a cold ceiling is liable to cause condensation. These coils together with radiators shown in Figs. 26 and 27 make it possible to keep the auditorium warm during periods of dis-use and also to heat it up prior to time of use without the expenditure of electric power to circulate the air; that is, the heating is accomplished in all normal weather by direct radiation without the use of the ventilating air, and it is not necessary to start either the supply or exhaust fan until the occupants are actually assembled. This cuts the electric power down to a minimum and is a most economical operating arrangement. While in many auditoriums the heating is accomplished entirely by the hot air these are not as economical to operate unless kept constantly in use and even then require more electric power than auditoriums supplied with direct radiators.

It will be noted in the plan Fig. 25 that a revolving damper is shown. This damper is arranged so that all the fresh air supply going to the auditorium above is carried thru on one side of the damper and all the exhaust air coming from the auditorium is carried thru the other side. The damper is arranged in such a

way that one of the large ducts is connected to all ceiling registers, the light girdle and other openings above the floor, while the other duct is connected to the vent spaces under the main floor and under the gallery floor into which all mushrooms and other floor outlets are connected. A simple turn of this damper will change the supply fan so that the fresh air will enter all of the top outlets while the exhaust air is pulled out of the floor outlets by the exhaust fan. Reversing the damper causes a reverse of the entire system—that is, the fresh air is then directed into the vent space beneath the auditorium floor and under the gallery floor issuing into the auditorium thru the mushrooms while at the same time the foul air is withdrawn from the ceiling registers under the gallery and the light girdle in the ceiling, changing in the briefest possible time from what is termed the “down-supply” system into an “up-supply” system.

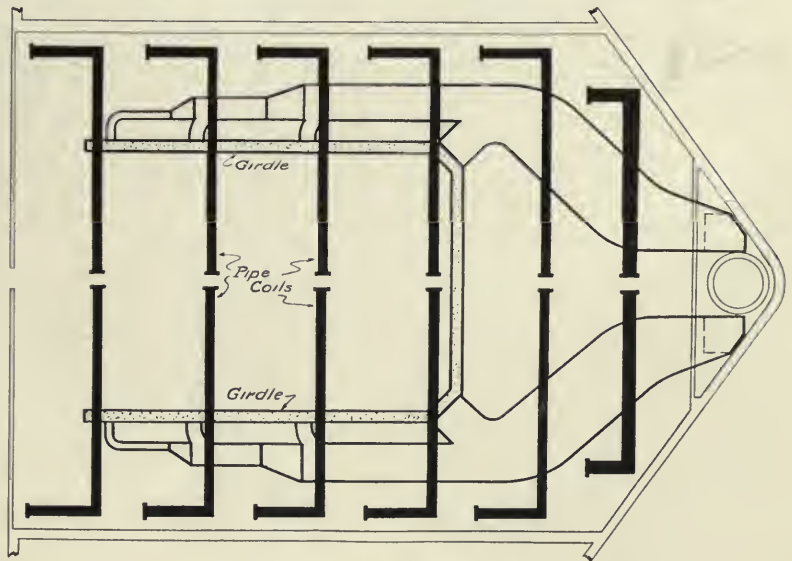


Fig. 29.

Now the desirability of this will not at first be apparent until it is remembered that the presence of a large audience in an auditorium makes the problem one of cooling rather than heating. This at first would seem to require only that the radiators be shut off and the ventilating air be allowed to enter at a low enough temperature to accomplish the desired cooling effect. While this in reality would accomplish the cooling required, the cold air falling on the unprotected heads of the audience results

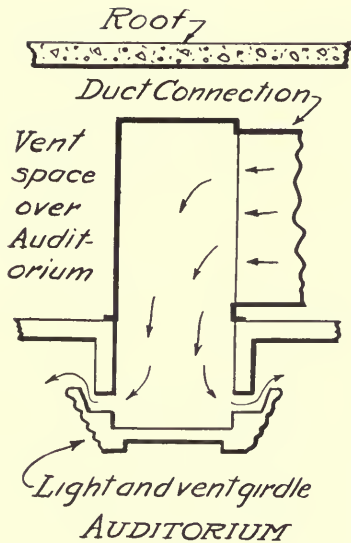


Fig. 30.

in unpleasant and dangerous draughts quite similar to those obtained from opening an outside window, except perhaps that they are of greater volume and not so low a temperature. The result, however, is decidedly undesirable. This can be obviated by simply turning the damper when the temperature in the auditorium begins to rise enough to demand cold air and feeding air from the bottom. This air does not come in at low enough temperature to cause discomfort to the feet and lower portions of the body which are better protected against the cold than the head and neck. By the time the cooler air has risen to the breathing line it has been more or less tempered both by the bodily heat and the mixture with the air already in the room so that it is not only less noticeable but the

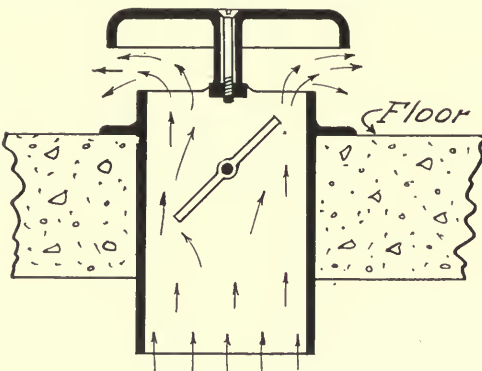


Fig. 31.

draft dropping towards the floor has been entirely eliminated.

If the reader is not familiar with what is meant by a mushroom in the floor a reference to Fig. 31 will indicate its construction clearly. The ordinary mushroom is six inches in diameter.

The school boards who place direct radiators in their buildings including the auditorium and supply air for ventilation only have the most economical system to operate. Those who install the reverse damper in their auditorium systems have not only the most economical but at the same time the most satisfactory system.

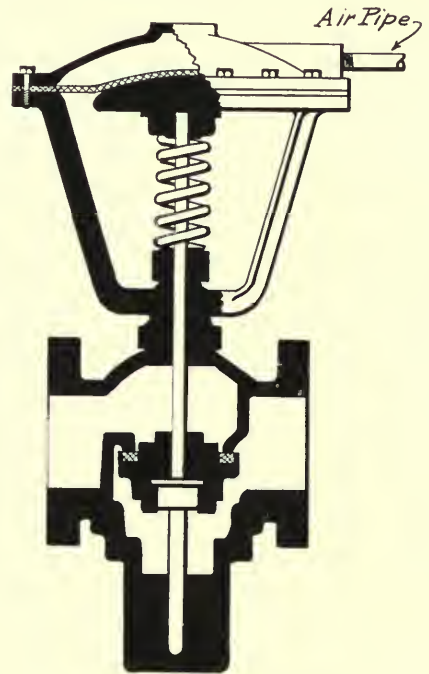


Fig. 32.

All that has been said regarding heating systems in the foregoing chapters has been stated with a presumption that automatic regulation will be installed. By this it is meant that on each radiator will be placed a valve similar to that shown in Fig. 32, and that each mixing damper will be controlled by an air motor similar to that shown in Fig. 33. It has been proven that it is an absolute impossibility to maintain proper temperature throughout a school where the radiators or in fact any other source of heat must be controlled by the individual teacher or by the janitor. This is largely due

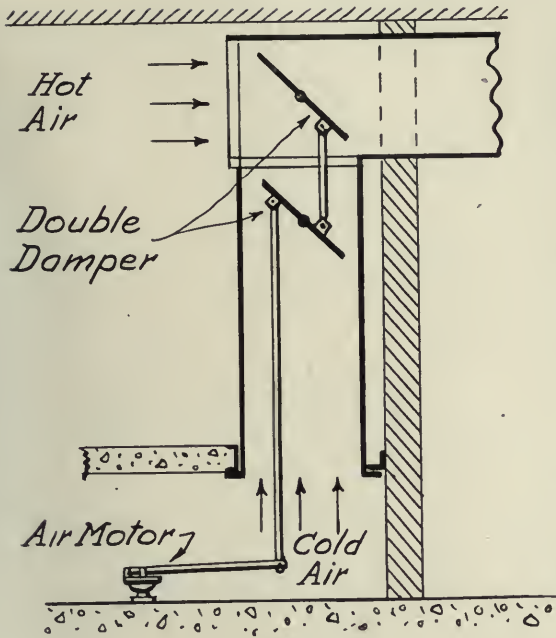


Fig. 34.

to the personal preferences of the various individuals in charge of the rooms, some preferring a cool room perhaps, 65° or even lower, and others preferring a hot room, 75° or slightly higher. Trouble is also caused by the teachers neglecting to maintain proper temperature when interested in their other duties. An immense amount of school money is wasted because the average teacher when feeling warm finds it much easier to pull the window down from the top or raise it from the bottom than to go around and manipulate two or three radiator valves. Thus, the heat obtained by burning coal

under the boiler is radiated in room after room where it is not required simply because it is impossible to force the attention of those in charge to the difficult proposition of keeping their thermometers between 68 and 70 degrees.

Automatic regulation is obtained generally by compressed air which is run thru the building in very small pipes, to instruments located in each room, called thermostats. These thermostats are adjustable so that they will (at any desired temperature) open a valve in the air line. This valve permits the compressed air to enter a pipe which connects to diaphragm valves on the radiators similar to that shown in Fig. 32. The air operates the valve in one direction and a spring in the other. When the temperature gets too hot the thermostat closes off the radiator and saves the school board's steam.

At the same time the temperature of the ventilating air (if supplied thru a double duct system with a mixing damper, or thru the individual duct system with similar equipment) is also changed. The compressed air enters the air

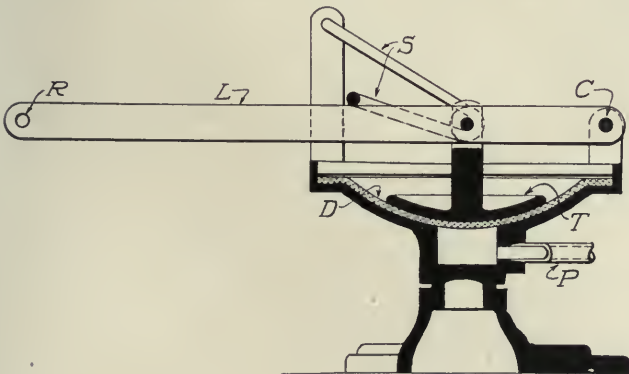


Fig. 33.

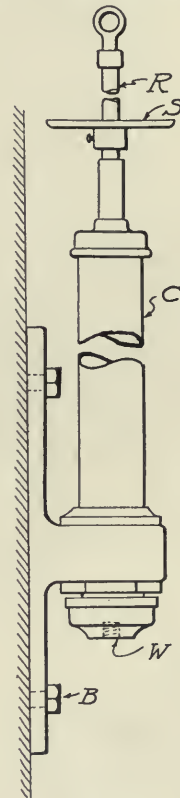


Fig. 35.

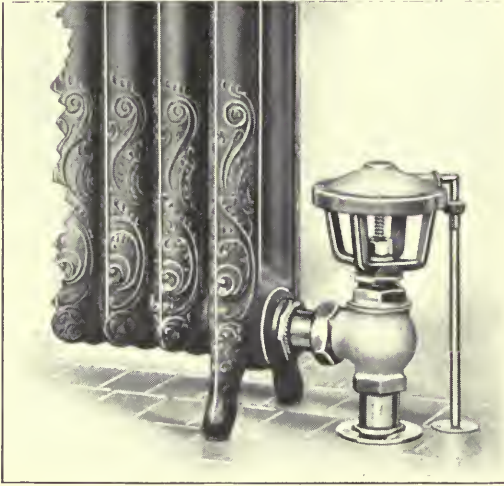


Fig. 36.

motor shown in Fig. 33 thru the pipe P, raising the diaphragm D, which moves the plate T and raises the lever L which is pivoted at point C. The lever L is connected to the mixing damper rod at R and moves the dampers so as to shut off the hot air and turn on the cold air if the room is too warm and vice versa if the temperature is too low. When the air supply is cut off the spring S brings the lever arm back to its original position. The method of connecting up one of these air motors to move the dampers in the flues is shown in Fig. 34.

The steam which is saved by such equipment is prevented from leaving the boiler and raises the pressure so that the damper regulator shown in Fig. 35 will shut the damper in the main boiler flue and thus check the fires. This damper regulator is nothing but a cylinder C in which the piston R is pushed up by the steam pressure, the pressure point at which it moves being determined by the number of weights which are piled on S.

It can easily be seen that with this equipment a rise in temperature outside of the build-

ing or the heating up of the rooms by the presence of the pupils conserves the steam the instant it is possible without underheating the rooms. In fact, it is claimed that automatic regulation has been known to save 25 per cent of the fuel which would otherwise have been lost.

In Fig. 36 is shown a photograph of thermostatic control applied to a radiator, while Fig. 37 shows an air motor controlling two dampers such as are used in the double duct system.

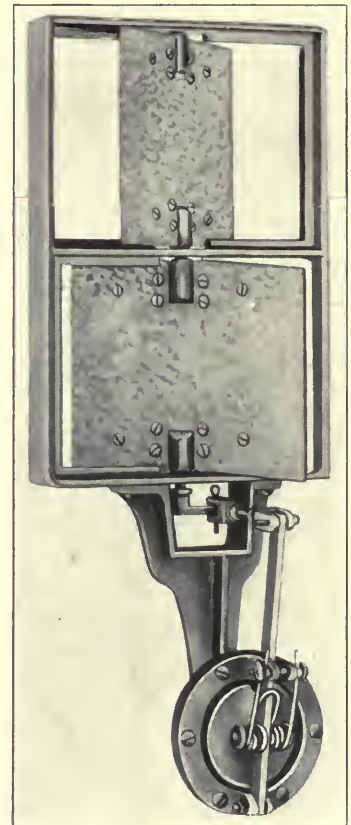


Figure 37.

CHAPTER IV

Ventilating Toilets and Laboratories

Possibly of even greater importance than the air supplied to and exhausted from classrooms is the method of ventilation employed in the toilets, since this has a direct bearing upon the health of the pupils. It is a well-grounded theory that no *fresh* air should be supplied to a room in which odors of any sort are created. This applies not only to toilet rooms but to locker rooms, kitchens and all other apartments which are operated under similar conditions. The reason for this is apparent when we consider the condition which results from not supplying such a room with fresh air, altho at first glance this treatment seems likely to result in just the opposite effect from that desired.

When a room is not supplied with fresh air and when at the same time air is withdrawn, a condition is created and maintained which is known as an "unbalanced air pressure"—that is to say, the air within the room (owing to the resultant partial vacuum), is of slightly less pressure than the surrounding atmosphere. As a result of this, every crack and leakage space thru which air can pass between the room and either the surrounding apartments or the outside of the building carries an air current passing inward *toward* the room in an effort to make up this unbalanced condition. The room in this case really becomes an actual partial vacuum of very limited degree and draws air into it from every side; this also results in an inward draft when the door is opened instead of a current of air in the opposite direction.

Under all normal conditions where air is exhausted from a toilet room and no fresh air is supplied, the odors created therein do not pass into the rest of the building but, on the contrary, the air from the rest of the building constantly passes inward to replace that withdrawn from the room by the vent flue. This, in practice, has been found to give the best results of any known method of treatment of toilet rooms. Unless, however, a fan is connected to the toilet room exhaust its action is not likely to be positive.

It is true a great many schools install heaters in these "aspirating" flues consisting of steam

pipes or radiators which heat the air after it leaves the room and create a suction somewhat like a chimney. This, however, is not as positive as the fan and the highest class of school work invariably employs separate toilet exhaust fans. Care is also taken that the toilet exhaust flues, while they may be connected with each other, are never in any way connected to the flues from other rooms in the building. It has happened more than once (when such an experiment has been made) that the exhaust air from the toilet room, at periods when the fan was out of commission, passed up its own flue to the flue from another room and then dropped back down the second flue into the building again. Therefore, the toilet exhaust system should be kept absolutely separate and distinct, and, at the same time, the maximum beneficial effects should be obtained by the use of the exhaust fan to secure positive movement of the air.

The only subject remaining for discussion on the toilet room exhaust system is the location of the exhaust outlet. On this point there is great difference of opinion, many preferring the exhaust outlet at the ceiling, near the door, while others, equally positive, advocate the location of the outlet near the door but at the floor instead of at the ceiling. In the opinion of the writer this disputed point is quite immaterial as the ideal point to catch an odor is at the place of generation and not after it has floated perhaps across the entire length of the room before passing into a register.

One good method of installing toilet outlets consists of concealing the flush tanks over the water closets with a boxing made of the same material as the closet partitions, this boxing having an opening over each closet as shown in elevation Fig. 38.

A cross section of this box, which will make the construction much clearer, is given in Fig. 39. There are, however, objections to this casing among which may be mentioned that it usually makes the tanks inaccessible, it is rather unsightly and, besides this, it is not so efficient as a register placed directly back of the water

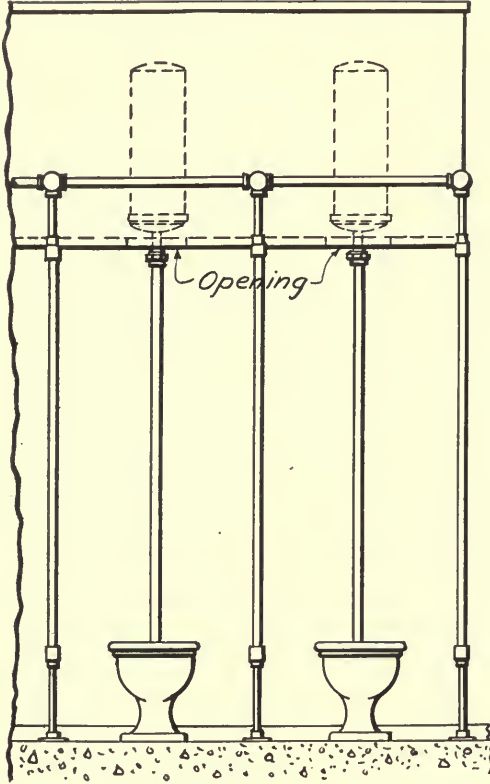


Fig. 38.

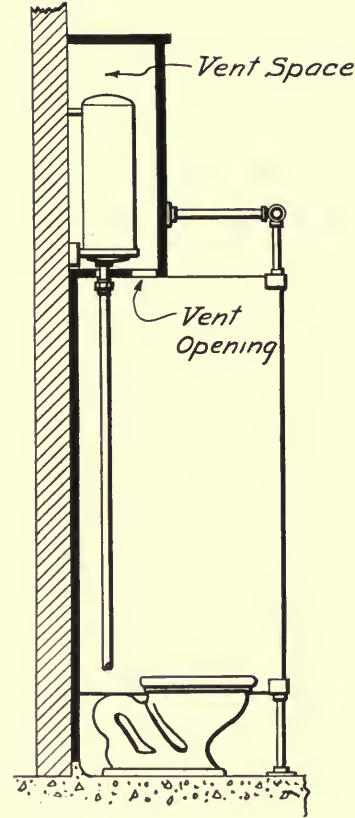


Fig. 39.

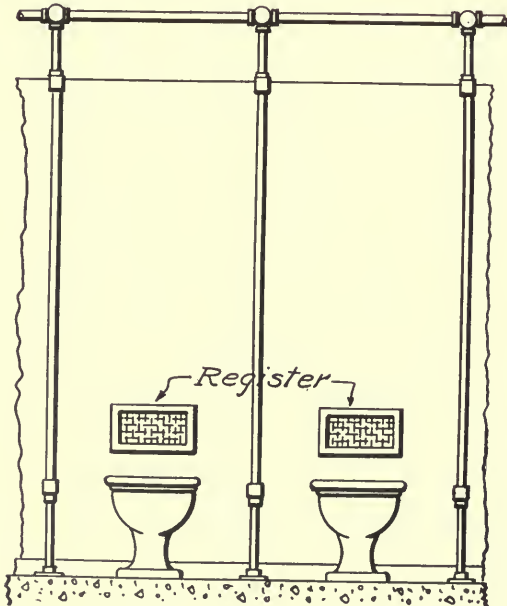


Fig. 40.

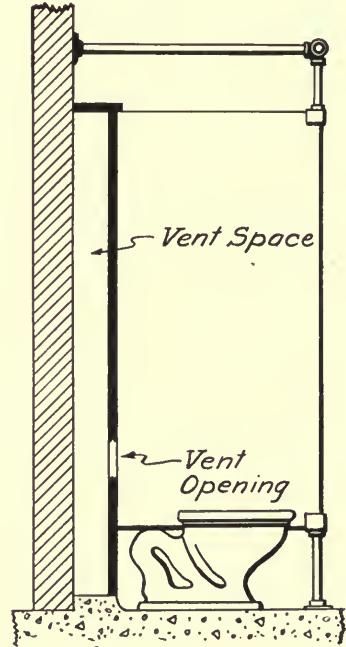


Fig. 41.

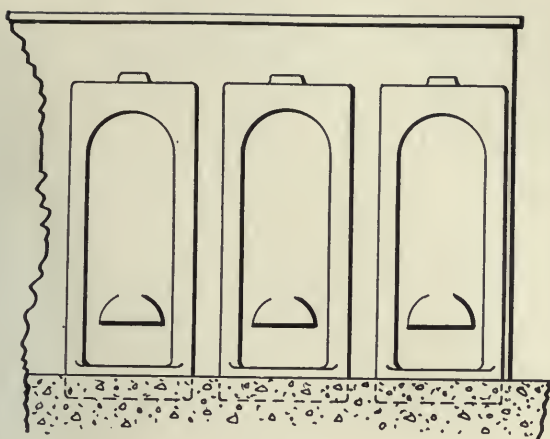


Fig. 42.

closet in the manner shown in Fig. 40. This register opens into a vent space which is formed by setting the alberene, marble or slate lining (which forms the rear of the stall) out a distance of six or eight inches so as to form a vent space, this being clearly indicated in the cross section, Fig. 41.

Still another method of ventilation for water closets is obtained by the use of the local vent, which will be taken up later under the discus-

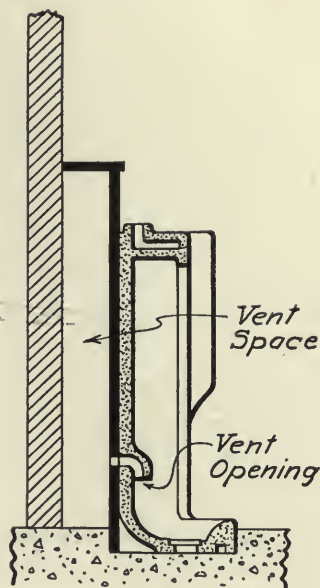


Fig. 43.

sion of plumbing fixtures. This local vent connection extends from the back of the closet into the partition which is located some distance out from the wall the same as indicated in Fig. 41, the local vent connection serving identically the

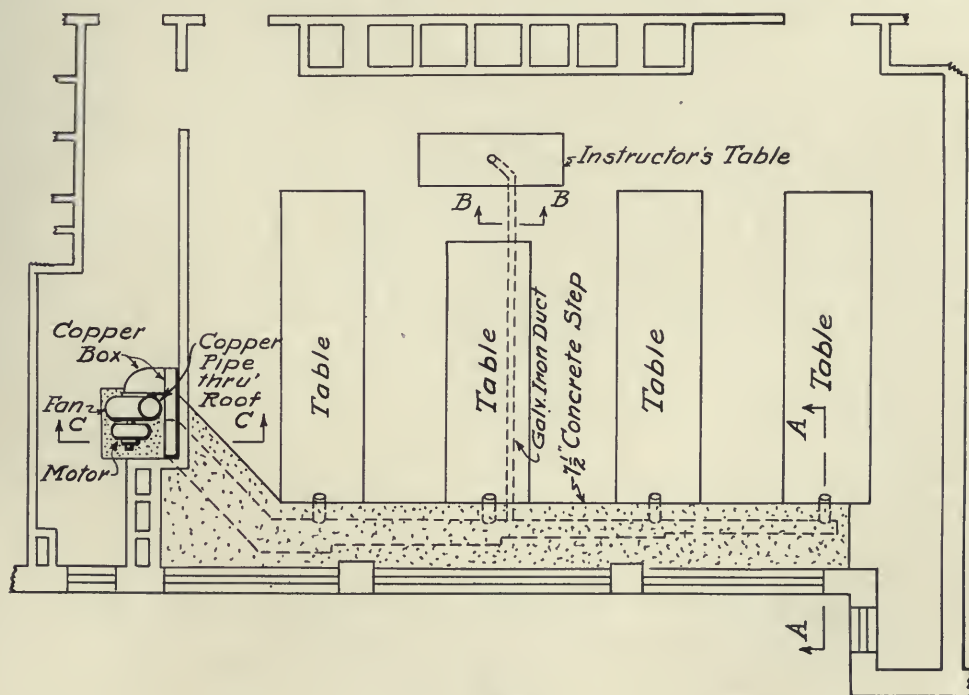


Fig. 44.

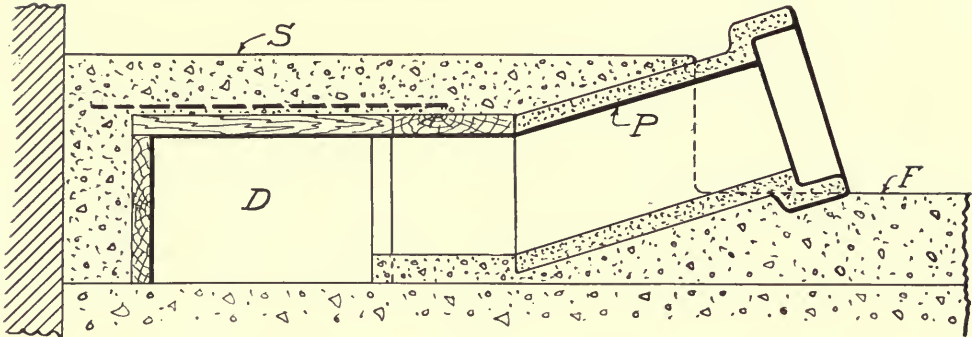


Fig. 45.

same purpose as the registers in Fig. 40. There are also certain sanitary objections to the use of the local vent. These will be treated later.

In the boys' toilet rooms will occur a type of fixture which is even more exacting in its ventilation requirements than the water closet; this is the urinal which is built in several forms. Fig. 42 shows an elevation of three "stall" urinals in which a vent opening is provided near the bottom of the fixture and a vent space is located behind (cross section, Fig. 43). These vent spaces must in every case be connected with the vent flue, and the sum of all the vents must equal a total area sufficient to pass out the required amount of air to secure satisfactory ventilation in the room.

Where "trough" urinals are used the construction is largely similar to Fig. 43 with the exception that the back slab of the urinal is stopped off a few inches above the bottom of the trough, allowing the air to pass under this slab and into the vent space behind. With the use of the "lip" urinal the best results are obtained with registers placed immediately above the fixtures similar to the arrangement shown for water closets in Fig. 40 with the exception that the registers, of course, come much higher above the fixture.

Another part of the school which requires careful treatment for ventilation is the chemistry laboratory where poisonous acid fumes are developed. In general, it may be said that the

chemistry laboratory may be arranged in one of two ways. First, the mixing and handling of chemicals may be done by the pupils at the tables. In this case each pupil should be provided with an individual exhaust hood which has a gooseneck connection to a pipe running underneath the table. Second, the experimenting may be done in a group of glass covered cases having sliding glass sash, the tops of these cases being connected into an exhaust system which discharges to the outer air.

Where the mixing is done at the tables it is growing to be the custom to omit the hoods and use a grating in the table into which many of the fumes fall naturally owing to the fact that they are heavier than air. When such an arrangement is used the greatest difficulty comes in getting the exhaust pipes from the tables over to some common point where an exhaust fan can be located to discharge these fumes to the outer air.

It is never desirable to run this piping on the ceiling of the room below, altho this is the ideal location from a purely engineering standpoint. When the pipes are so run, they are accessible, can be easily inspected and require no tearing apart of the structure for renewal. These pipes, however, must in all cases be constructed of acid proof material or at least

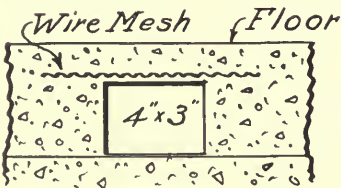


Fig. 46.

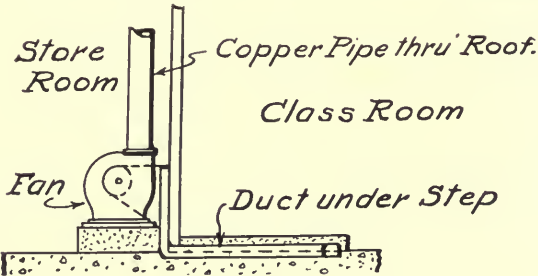


Fig. 47.

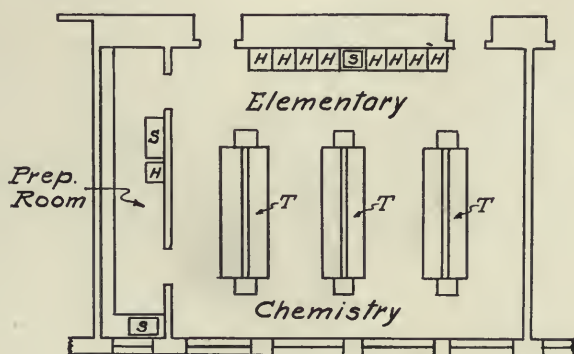
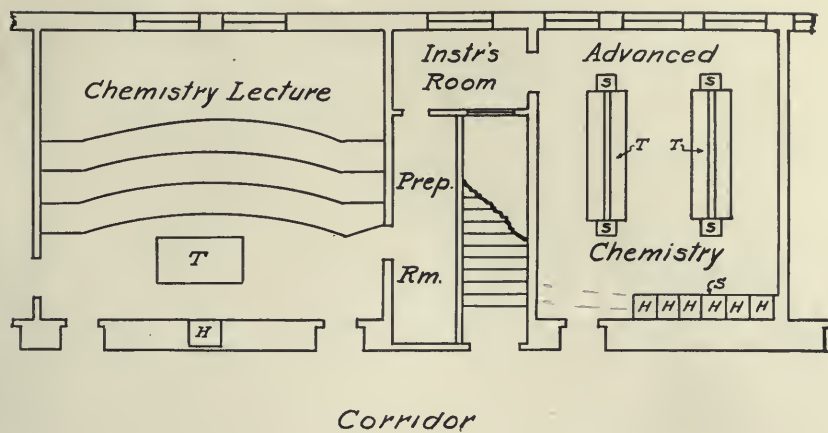


Fig. 48.

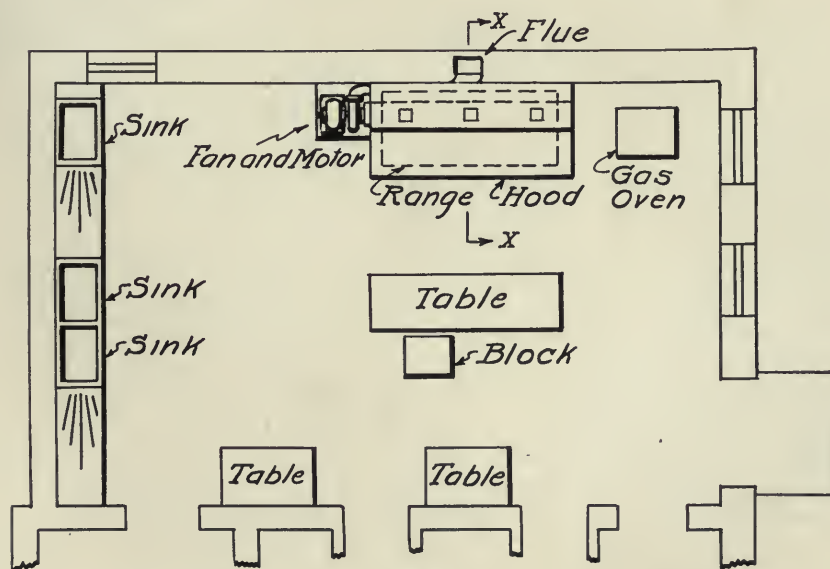


Fig. 50.

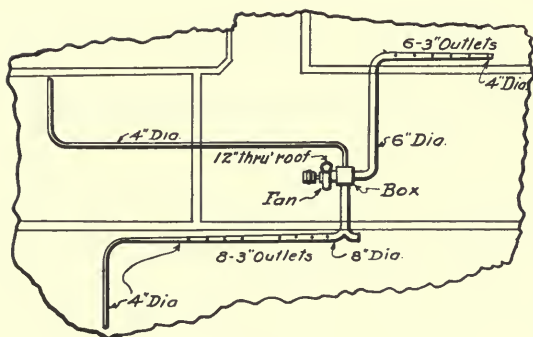


Fig. 49.

material which is *nearly* acid proof. The ideal fume exhaust is made either of tile pipe or concrete. Where it is impractical to use either of these two, copper pipe is substituted. The fan is usually made of cast iron coated with acid proof paint and has a wheel made of "monel metal," which is a practically acid-proof metallic composition.

A laboratory using the individual method is given in Fig. 44, the fumes in this case being carried under a concrete step which is made $7\frac{1}{2}$ inches high all along one side of the room and extending over to the fan.

A cross-section of this step on line "A-A" is shown in Fig. 45, in which S is the top of the concrete step, F the finished floor, D the duct under the step and P a piece of tile pipe into which the flue running under the table is connected. A small flue is also extended over the instructor's table, a cross section of this on line "B-B" being shown in Fig. 46. The duct under the step connects into a copper box opening into the suction side of the fan which is located in an adjoining room. The fan discharges thru a copper pipe out of a copper ventilator set well above the roof. An elevation of this apparatus on line "C-C" and the connection between the duct and the fan is given in Fig. 47.

Fig. 48 is a typical layout taken from a new high school in which the glass case arrangement is utilized. In this plan the tables are indicated by T, the sinks by S and the glass cases with hoods by H. Owing to the fact that this chemistry laboratory is on the top floor (a common location in modern schools) it was possible to connect these hoods with three inch copper pipes run straight thru the ceiling to a main copper duct located in the attic space above, a

plan of which is given in Fig. 49. All the main ducts in this space are connected into a suction box from which the fan draws the fumes and discharges them thru a roof ventilator. In an installation of this kind it would have been possible to use tile pipe had it not been for the fact that the ceilings over the classrooms are only "hung" ceilings and were not regarded as substantial enough to support a tile duct with its accompanying concrete slab. With the exception of the special chemical fume exhausts, all chemical laboratories should be ventilated with supply and exhaust ducts the same as other classrooms.

Kitchen ventilation follows out the general rule, previously laid down, of exhausting the air and not supplying fresh air to the room. This may be done by an exhaust flue with a register located at any convenient point. Much better satisfaction is given when the odors are caught "at the point of origin" which is generally over the stove, soup kettles, vegetable boilers and similar odor producing kitchen equipment. Owing to the fact that most of the odors are given off in a heated condition so that their temperature is higher than that in the room they tend to rise and seek the ceiling, where after a time, they become cooled and drop back to the floor again, reaching all parts of the room by this method of circulation.

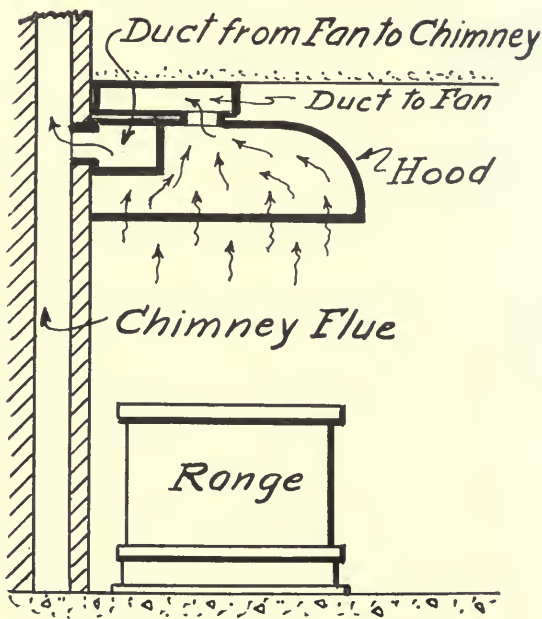


Fig. 51. Cross Section X-X of Fig. 50.

To arrest these odors as soon as possible a hood is generally extended over all the troublesome equipment. A graphic example on a small scale is shown in the little kitchen plan given in Fig. 50, where a hood is placed over the range and has an exhaust duct (connected to a fan) placed between the hood and the ceiling. This is shown more clearly on the cross section along the line X-X given in Fig. 51. Numerous outlets connect the hood into the exhaust duct to the end of which is connected a small exhaust fan. This fan discharges into a small duct carried along the inside of the hood, as shown. It opens into the chimney flue. By using individual hoods and exhaust equipment of this sort the odor from a soup kettle can be killed without making it necessary to run the entire exhaust system for the whole kitchen until later.

In the lunch room, owing to the large number of pupils present at times, it often proves impractical to follow out the scheme of exhaust *only*, inasmuch as the quantity of air will be excessive on the "30 cu. ft. per minute per pupil" basis. Therefore, in lunch rooms a compromise is often made by exhausting the full 30 cu. ft. and supplying say 15 or 20 cu. ft. This will still cause an inward leakage at all points and yet does not absolutely rob the pupil of fresh air. These exhaust registers are preferably located near the doors, the idea being to catch any air of the room which might be moved toward the openings leading to other portions of the building by the swinging of the doors or by other causes.



A HIGH SCHOOL LUNCH ROOM.
(Grover Cleveland High School, St. Louis, Mo.)

CHAPTER V

Toilet Fixtures

The subject of plumbing is one in which every school board is vitally interested. While the heating and ventilation of a building contribute largely to the comfort of the occupants, the plumbing acts directly, and almost immediately, upon their health. Altho it is undoubtedly true that the lack of ventilation may in time have a bad effect on the physical welfare, epidemics and serious diseases are not likely to be created; with faulty plumbing epidemics and diseases are bound to occur and few parents, indeed, when such an event stirs them deeply, are inclined to be lenient in their judgment of the authorities at fault.

Strange to say, the average architect has but a very hazy idea of the mysteries of plumbing, while persons not directly interested in construction work are completely beyond their depth. One of the most remarkable facts in connection with modern sanitation, (and undoubtedly the cause of much of the general ignorance on the subject) is the recent date of the development of sanitary science. It has in fact, progressed to its present state, almost from its infancy, within the last fifty years, and the modern syphon-jet water closet can hardly be said to have been in common use previous to 1900. Today, even among sanitary engineers of acknowledged standing, there are radical differences on what shall constitute correct and incorrect plumbing work.

To a great extent, especially in cities of moderate size, the piping of plumbing fixtures is regulated and controlled entirely by local ordinances. The requirements of these local enactments vary widely, sometimes even conflicting in important details.

Such being the case, the writer is unwilling to make hard and fast statements regarding many sanitary details, but will rather present accepted generalities and some warnings against positive dangers upon which no question can be logically raised.

The primary purpose of the modern plumbing system is to supply water in the proper condition and at the proper temperature to the various points in the building where required, and

to remove such water, together with other waste matter, in an inoffensive and sanitary manner. A proper system includes all fixtures, piping and other equipment necessary to accomplish this in the most satisfactory way.

Modern plumbing is based on the theory that drainage pipes and sewers become foul and generate a gas (commonly termed "sewer gas") which is most dangerous to health. Upon this accepted fact the waste pipe from every fixture is trapped at the closest possible point to the fixture. A trap is usually a bend in the waste pipe (Figure 52) somewhat like an inverted syphon with waste water standing in the bottom and thus "water-sealing" the pipe so that no air can pass from the room into the sewer—and (what is more important) so that no air or sewer gas can pass from the sewer into the room. Figure 53 also shows a common type of trap known as a "pot" trap often used for bath tubs, shower baths, etc., its purpose and action being similar to the first type described.

To prevent a "slug" or rush of waste water from drawing out, by syphonage or suction, the water which should remain in the trap, practically every trap is "relieved" or "back vented." This relief is afforded by a vent connected to a pipe opening into the outer air and serves to break the syphonic action so that the contents of the trap are always intact.

Some traps, such as floor drains, leader traps, etc., it is not desirable to vent, since a vent line causes a current of air and makes the evaporation of the water in the trap much more rapid. On fixtures in common use this evaporation is negligible as the water in the trap is renewed with every discharge of the fixture. Where traps are liable to remain for considerable periods without use, and therefore without renewal, it is customary to omit the vent.

The division of plumbing work with which the school board members are most intimately concerned is the selection of the type of, and material for, the plumbing fixtures. For instance, water closets may be of the local vent type; they may be of the range type, syphon jet, or wash down; they may be vitreous, porcelain, or enam-

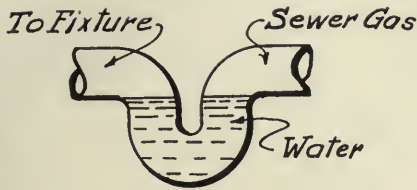


Fig. 52.

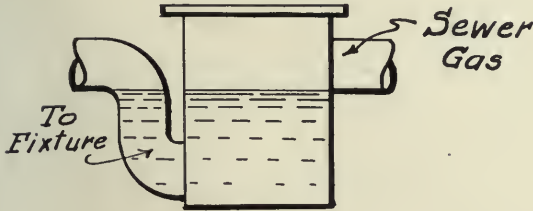


Fig. 53.

eled iron. Urinals may be of the stall, lip, or trough type, either locally vented or not; they may be made of vitreous ware, porcelain ware, slate, glass, alberene stone, etc., etc.

To begin with, what is the distinction between vitreous ware, porcelain ware, and enameled iron? All are white, all are used for various fixtures and, to the casual observer, might easily be mistaken for each other.

Vitreous ware is plain, glazed china, similar in makeup to the well-known china tableware. It is produced by firing a clay core in a kiln until it vitrifies, and then glazing it by dipping in a glazing solution which is fused to the clay body by another firing. The chief advantage of this ware is its impervious and non-absorbent body which is thoroly vitrified. It may be distinguished most positively from porcelain ware by what is known as the "aniline ink test" in which a chip is immersed in aniline dye for a period of several hours. At the end of that time the piece is broken thru the fractured side and the distance that the ink has penetrated the fractured surface is measured. Good ware will not show a pink discoloration over 1-32 inch deep.



Fig. 54.

Of course, for plumbing fixtures this material is almost ideal, altho the fixture design is limited by the potter's skill to form the clay, and the ability of the kiln to fire such forms without distortion. This ware is the most expensive of any used for fixtures, but should be required wherever the financial considerations permit, and where the fixture designs can be produced in vitreous form.

As an example, water closets are almost universally vitreous ware—and *should be*—other materials for water closets being prohibited by many of the first-class plumbing codes. No school board should allow other than vitreous closets in any school under its control.

Porcelain ware, solid porcelain—or "porcelain china" as some manufacturers delight to characterize an inferior ware—is produced in much the same manner as vitreous ware, except that the body is composed of a clay mixture which is fired at much lower temperature than the vitreous ware, and which does not vitrify. Therefore, while porcelain looks and feels like vitreous ware, the slightest chip of the glazed surface exposes the porous base. This base quickly takes up water and impurities and soon becomes foul. It will not stand the aniline ink test without the ink penetrating a much greater depth than 1-32 inch.

Porcelain ware is largely used for lavatories, washtubs, and other fixtures where the sanitary requirements are not as exacting as in water closets.

Up to the present time the stall urinal has not been commercially produced in vitreous ware, owing to the large size of this fixture and its failure to stand the excessive kiln temperature without serious warping. Some manufacturers have succeeded in producing a stall urinal eigh-

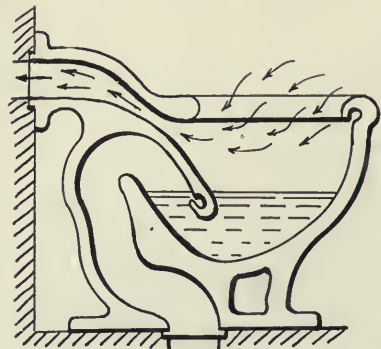


Fig. 55.

teen inches wide of vitreous ware, but the regular 24 inch width has so far defied their art.

Enameled iron ware is produced by making a fixture out of cast iron, and then coating it with a white enamel glaze, which is fused in a furnace. This results in the uniting of two dissimilar substances with different co-efficients of expansion. These fixtures are exceedingly liable to have the coating crack when very hot or cold

Slate is much used in schools for the construction of trough urinals and so-called "slab work" which includes toiletroom wainscots, water-closet partition, shower-bath stalls, etc.

Marble is used for slab work of particularly fine character, but is usually too expensive for school purposes.

Alberene stone is a natural, dark-gray, mottled stone, streaked with dark veins, and is

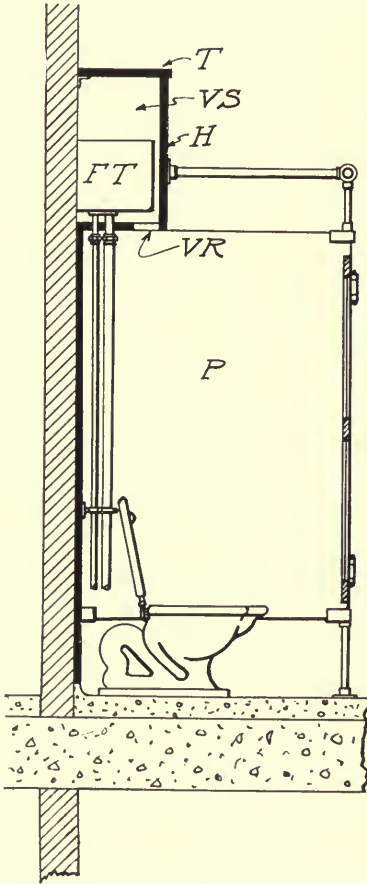


Fig. 56.

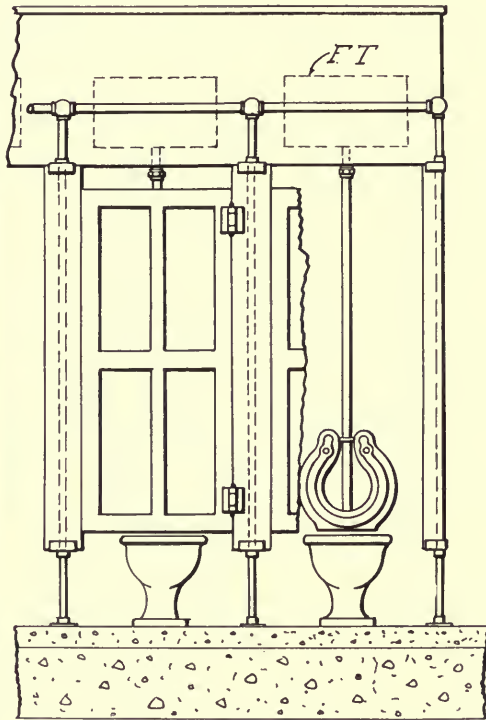


Fig. 57

water strikes them. Also, the coating is very brittle, a slight blow chipping it off and exposing the iron below. This, while not absorbent, is highly corrosive. It soon rusts, and produces an offensive looking and unsanitary fixture. The use of enameled iron today is gradually being confined to sinks and slop sinks, cheap bath tubs and lavatories.

Galvanized iron ware is little used except for sinks and slop sinks. It is not to be recommended for schools.

much used in schools for trough urinals, slab work, table tops, chemical sinks. It is particularly well adapted for acid demonstration tables, being practically acid proof. The joints are made by grooving and inserting a continuous metal clamp which is buried in the joint and made water proof by the use of litharge.

From this varied assortment the school plumbing fixtures must be selected and their surroundings must be decided upon.

So far as the water closets are concerned,

there is only one kind which is generally approved for school use, this being the "syphon jet" type of vitreous ware. In this type the syphoning out of the contents of the bowl is assisted by a jet which helps to raise the water in the closet over the high point of the syphon at the time of discharge. This action is illustrated in cross section by Figure 54.

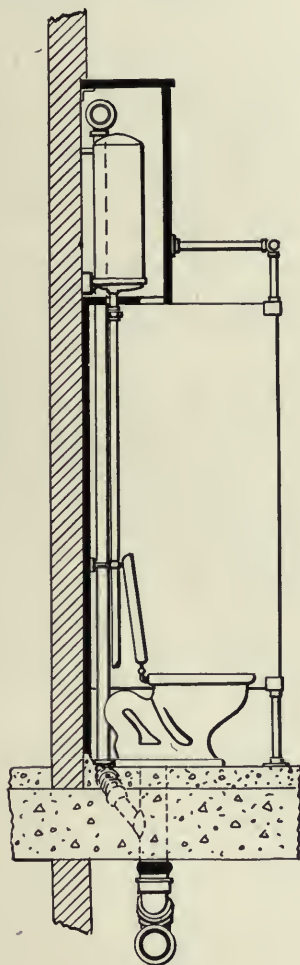


Fig. 58.

The wash-down closet is quite similar to the syphon jet except that the jet and its action are lacking, and this closet, therefore, fails to have the immediate and superior action of the syphon-jet type. It is a cheaper and less satisfactory substitute for the jet closet, altho its use is not by any means a serious transgression of the modern sanitary requirements.

Let me warn school boards, however, against

the use of the "range" water closets which are now obsolete, having been recognized as radically bad from the sanitary standpoint. A safe rule to use in selecting superior types of plumbing fixtures is the one which says: "Each and every square inch of surface on a fixture not cleaned and scoured off at each flush is a discount to its sanitary properties." Just see where

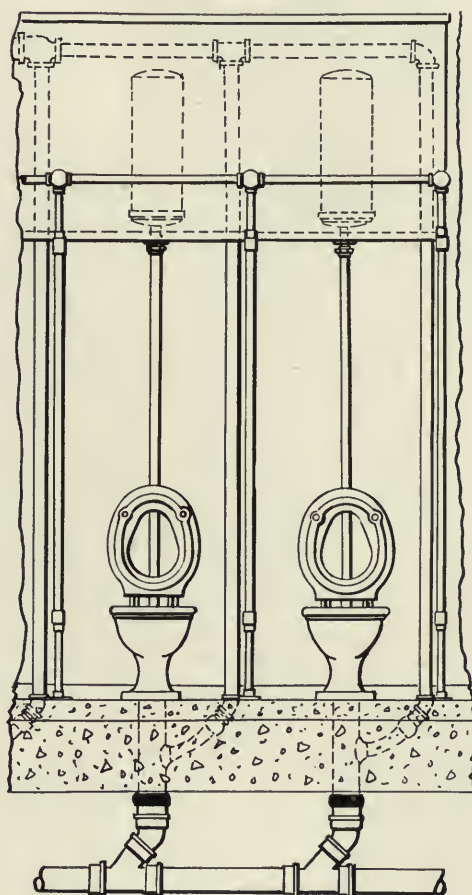


Fig. 59.

the range water closet stands with its large exposed and unflushed surface. It cannot even be made from vitreous ware, owing to its enormous size.

Having decided on a vitreous syphon-jet closet the next matter for consideration is whether it shall be locally vented or not. At the time the matter of ventilation of toilet rooms was being touched upon the application of local ventila-

tion was mentioned, and it was noted that this subject would be discussed more fully under the fixture itself.

In Figure 55 is shown what is known as the local-vent water closet, or closet with "raised rear vent," sometimes also called a "Boston" vent. This vent is formed directly as an integral part of the fixture and is usually connected thru the wall into a "utility corridor." This "corridor" is the space for pipes back of the plumbing fixtures and is vented directly into a duct carried to the outer air.

From a *ventilation* standpoint it is extremely desirable to catch all odors at their point of origin rather than to draw them across a large portion of the room before they find egress thru the vent register. From a *sanitary* standpoint the use of the local vent is debatable.

Many maintain that the vent and flues connected to it soon become so foul as to constitute a detriment rather than an advantage. On the other hand its use seems to be on the increase in schools where the most up-to-date equipment is provided. It is interesting to note that the Schenley High School in Pittsburgh (under construction in 1915-1916 and which cost nearly a million dollars) has employed locally vented water closets almost exclusively. In fact the local vent closet has been officially adopted by the Pittsburgh School Board as the standard type of closet for all their school buildings.

The Montclair (New Jersey) High School costing about \$700,000 and completed in 1915, uses locally vented water closets for all pupils' toilets.

The Elizabeth (New Jersey) High School costing about \$500,000 and completed in 1914, did not employ local vents, but the remodeling and enlargement of the New Lebanon School at Greenwich, Conn., (completed in 1915) does.

In none of these cases, either with or without the vent, has the mortality or health rate been seriously affected, so we may rest assured that the opponents of the local vent are exaggerating to a certain extent, at least.

Selecting the type of water closet also includes the means of flushing. Today there are three standard means for flushing closets—the gravity tank, the pneumatic compression tank, and the flush-valve.

The gravity tank may be a high tank located near the ceiling or a low tank set just above the fixture. Each of these tanks fills with water from a small pipe which is closed off at the proper time by a valve, in the tank, operated by a copper float.

To flush the closet a chain pull or small lever handle is used which allows the water to flow out of the tank thru a good sized connection into the closet, giving the required amount of water within the needed time. Gravity tanks are cheap but are not recommended for school work owing to the ease with which they can be tampered with and put out of order. They may be installed, when protected from mischievousness, as they are in the Elizabeth (New Jersey) High School. A protected tank is shown in Figures 56 and 57, P indicates the partition, FT the flush tank, VR a vent register, VS a vent space, H an alberene side and T a removable top.

Far better for school work is the pneumatic compression tank which is illustrated in Figures 58 and 59. This tank is normally full of air and the closet seat is raised in the front about 1½ inches by a spring. When the fixture is used the depressing of the seat to its proper level opens the valve on the supply pipe so that water rushes up and partially fills the tank, compressing the air above it. When the seat is released the supply-pipe valve is closed and the flush connection into the closet is opened. The water in the tank, driven both by gravity and the compressed air above it, is forced down the supply pipe and performs the flushing operation.

Since it is nearly an *impossibility* to use this closet without its flushing automatically, it is particularly desirable where very young children are present or a foreign population is to be served. The tank will not operate satisfactorily on less than twenty pounds per square inch water pressure at the closet.

CHAPTER VI

Plumbing Fixtures

The third type of water closet flushing device consists of a flush valve so designed as to permit almost the free and instant opening of the water pipe into the closet and then gradually shutting off the flow. While the shut-off is automatic, the operation of the valve must be produced by manipulating a push button or lever handle. These flush valves are used almost exclusively in larger buildings of public character and are being received with more and more favor in schools, altho they are more expensive than a compression or gravity tank. A favorite method of installation, where utility corridors are used, is to place the valve in the corridor and to operate it by a push button extended thru the corridor wall (Fig. 60). This arrangement has two advantages; the valve is secure from meddling, and repairs can be made by the janitor without entering the toilet room. This, of course, is specially desirable in girls' toilet rooms.

Flush valves can be obtained which operate on as low as six pounds of water pressure, altho not less than ten pounds is recommended by the writer to avoid the possibility of trouble. Small piping will not do for the valves; the common size of the flush valve pipe branch must be $1\frac{1}{2}$ in., or at least $1\frac{1}{4}$ in. Each valve should have a separate shutoff or stop valve, either entirely separate or incorporated in the flush valve, so

as to permit repairs to one fixture without putting the whole battery out of commission. This feature is desirable on all fixtures altho the first cost of such a large number of extra valves seems excessive.

Flush valves require a steady, even pressure to give the best results. For this reason they are usually installed in combination with a house tank—a subject which will be taken up later under the discussion of the water supply for the school building.

One other type of water closet, which deserves mention before leaving this subject, is the "wall hung" closet shown in Figure 61. This closet has been installed in several buildings, among which may be mentioned the Reading Terminal in Philadelphia and the City and County Building at Wilmington, Del. So far, its use in school work has been exceedingly rare. Yet there is no reason why it should not prove just as satisfactory in educational buildings as elsewhere.

The advantages claimed for this fixture are: ease of cleaning floors beneath, absence of dirt-accumulating joints at the floor, better circulation of air and the possibility of carrying the soil pipes at the back entirely above the floor in the utility corridor, instead of on the ceiling of the room below as is customary with the common closet.

The next fixture in sanitary importance is

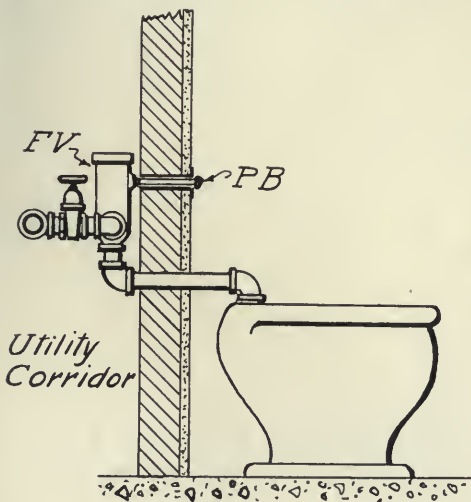


Fig. 60.

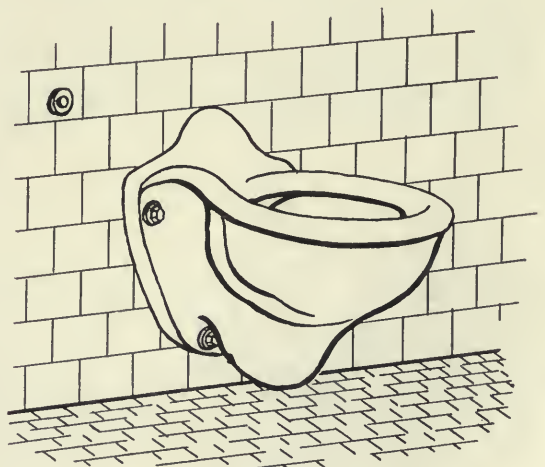


Fig. 61.

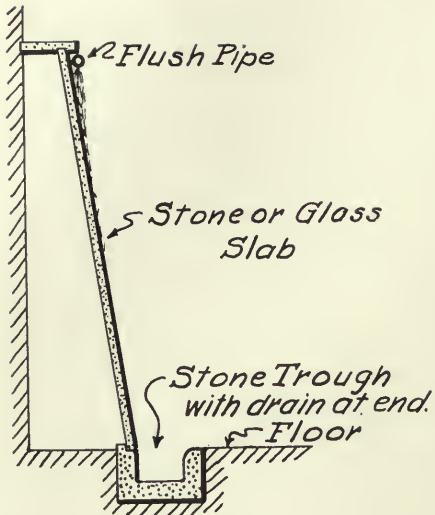


Fig. 62.



Fig. 64.

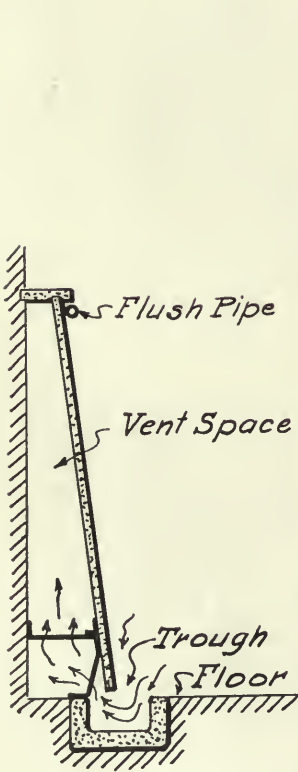


Fig. 63.

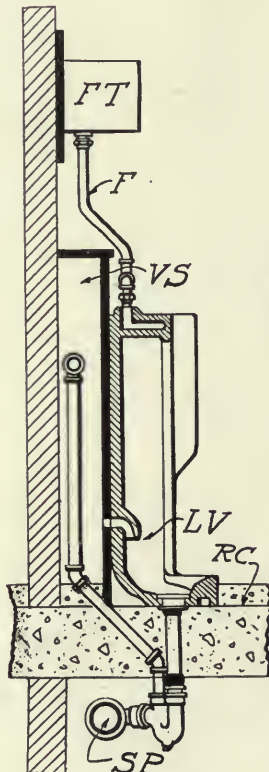


Fig. 65 A.

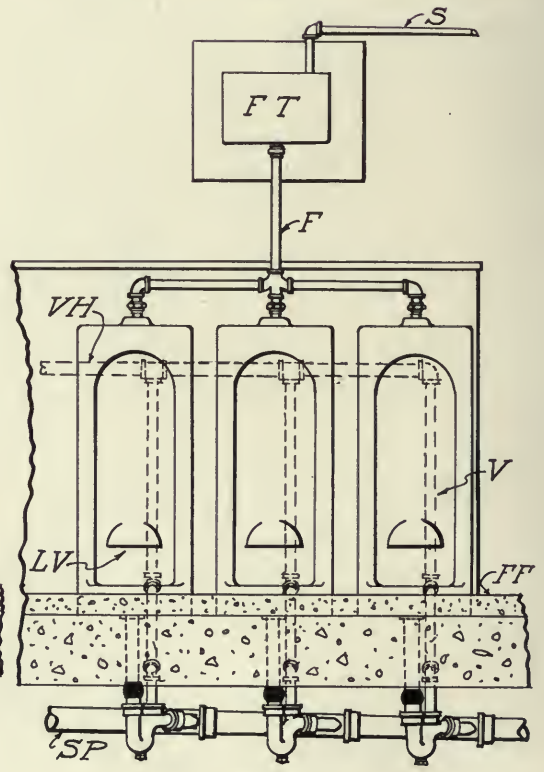


Fig. 65 B.

the urinal which has shown marked development in late years. The old, standard trough type (usually made of slate, glass, or alberene stone) is shown in Figure 62. In this type the flush pipe at the top is perforated and keeps the slab and trough washed off by a constant, or intermittent, flow of cold water. This type of urinal is being installed in many schools, but is rapidly losing favor because of its rather repellent appearance and excessive water con-

A step in advance from the trough urinal is what is known as the lip urinal. This fixture is illustrated by the photograph, Figure 64, in which it is shown with a flush valve attached. The lip urinal is very popular in older public building work but has been little used for schools. Altho cheaper than the stall urinal, later described, it requires a more or less expensive partition and backing of marble, alberene, or slate, so that the cost over all is



Fig. 66.

sumption when constantly flushed. It absolutely requires, by its construction, either a complete flush along its entire length or no flush at all. It can be readily seen that, with such a condition existing, economy in water consumption is impossible.

Figure 63 shows a trough urinal of the above style arranged for local ventilation and, while this eliminates some of the objectionable odor otherwise likely to arise from this type of fixture, it does not help the excessive water consumption.

nearly as much as the stall type. Moreover the floor under such fixtures is liable to be in an unsanitary state, requiring practically constant attention to keep it in proper condition.

The most satisfactory type of urinal for school use is undoubtedly the stall fixture shown in Figures 65A and 65B. These fixtures are flushed—in this case—by a flush tank FT thru the flush pipe F; they waste thru individual traps into the soil pipe SP, the traps being vented by the vents V into the vent header VH. As shown these fixtures are local vented at LV

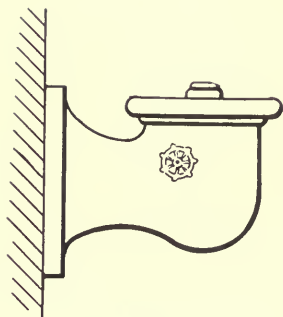


Fig. 67.

into the vent space VS, altho they are commonly installed without this arrangement.

These fixtures are generally set directly on the rough concrete RC after which the finished floor FF is carried up to and around them. It is not considered desirable to set the tops of these fixtures even with the floor owing to the liability of dirty scrub water, sweepings, and other foreign substances to find their way into the fixture. These urinals can be flushed with flush valves, and when so installed exhibit much economy in water consumption. A view of a typical battery installed in one of the new modern high schools is shown in Figure 66.

Another method of local venting this type of fixture consists of making a pipe connection from this vent chamber down to the waste pipe immediately under the fixture. The idea is that a draft will be created not only at the bottom of the fixture but in the upper part of the waste pipe as well. It is hard to definitely say that either method is much superior to the other as both have staunch advocates, and the writer has never been able to note any marked difference in favor of either.

Lavatories in school buildings should be made of vitreous, with spring or push button faucets to avoid waste of water. It is not believed that the so-called "Fuller" type of faucet is as satisfactory for school use as a good compression faucet built along modern lines. A lavatory with an integral back and a supporting leg is recommended, somewhat of the type shown in Figure 66. There is probably less chance, however, of going wrong on the lavatory selection than any other fixture. If a cheaper fixture than the one shown is desired, the leg may be omitted and the fixture supported from the wall by a cast iron wall bracket and small nickel plated lugs.

Still further reduction can be made in cost by substituting a porcelain lavatory or an enameled iron one, altho neither will stand usage so well as vitreous ware.

One of the greatest problems of the modern school is the drinking water. How to present to the pupils an adequate supply of cool and palatable water in a manner which is germ proof is a question of no small importance. In many states today, and in a much larger number in the near future, the common drinking cup is, or will be, illegal. More than this, there is great hygienic necessity in this prohibition so that it is a matter of wisdom that new school buildings be equipped with some sort of drinking fountain not requiring the use of cups.

Of course individual paper cups can be used, but there are numerous objections to this practice. Free cups will be wasted by the pupils and used for every conceivable purpose besides that for which they are intended. Cups vended by the "penny-in-the-slot" method are hardly practical especially in schools younger children attend. The supply of cups is constantly becoming exhausted resulting in the use of second



Fig. 68.

handed cups (or worse) until the supply is replenished.

The only practical way to avoid the danger of common drinking cups and the nuisance of individual cups is to install bubbling drinking fountains. These come in three general styles: the pedestal type, the wall hung type and the trough type.

Most drinking fountains of the trough type are improvisations from the old faucet-cup sink arrangement in which some sort of bubbler has been attached to the faucet. There are types, however, in which the trough or sink is deliberately used for one to six bubblers, thus making one waste connection serve all the fountains in the same trough.

The wall hung fountain, illustrated in Figure 67, is a cheap and satisfactory form of individual fountain. It is sometimes set in batteries of three, or even more.

Pedestal fountains have the advantage of being set out on a floor in any desired position, without regard for a wall. These can be obtained in many forms and styles from the extremely rugged, such as is installed in the East Orange (N. J.) High School (Figure 68), to the most advanced, foot-control vitreous fountain such as is installed in the Elizabeth (N. J.) High School (Figure 69).

The type of bubblers requiring pressure by the hands to operate are not likely to be as sanitary as the bubblers with a spring faucet or foot control and should not be used when avoidable.



Fig. 69.



Fig. 70.

Sinks are a comparatively rare fixture in schools excepting those of more advanced character. They may be divided into service sinks and sinks for teachers and pupils. The service sinks comprise slop sinks, kitchen and lunch-room and boiler room sinks. The pupils' sinks include domestic science sinks, chemistry sinks, arts and science sinks, etc., the teachers' sinks are limited almost entirely to demonstration table sinks.

In general enameled iron sinks are fairly satisfactory for service use. The boiler room sink is galvanized iron almost without exception. Where slop sinks are installed in toilet rooms adjacent to nice plumbing fixtures they are generally of porcelain, but when placed in slop sink closets accessible to the janitor only, galvanized iron is often substituted.

Both kitchen sinks and slop sinks should have backs—integral preferred—and valves control-

ling the supplies so as to regulate the flow of the water and to allow repair of the faucets without shutting down other fixtures. A good installation of a school kitchen sink is shown in Figure 70. Here the valves are set in the wall with the bonnet and wheel handle exposed.

Drain boards on kitchen sinks are coming into much wider use than formerly. The favorite board is built of ash as this does not

break the amount of dishes which a board of enameled iron will.

Cooking sinks are preferably vitreous, but porcelain is also much used. Demonstration table sinks are made of vitreous ware, porcelain, alberene, etc. These usually have ground tops and are set under openings cut in the tops of the table. Alberene is often used where acids are to be handled.



A SCHOOL LAUNDRY.

CHAPTER VII

Number and Location of Fixtures

After the school board has reached a definite decision upon the plumbing fixtures to be used, the question arises, How many, and, where?

It is indeed a hard problem to state, with exactness, the number of fixtures of each kind required for any given building. This is due to the general vagueness regarding the maximum seating capacity, largest probable number of occupants, etc., which usually exists at the time the building is designed.

Of course, the primary motive in the location of plumbing fixtures in any building is to place them in convenient and accessible positions where, at the same time, they will be inconspicuous. It is, however, a fact to be regretted that many schools, even at the present time, are arranged by school boards to have their main toilet rooms for both sexes in the basement. It must be granted that the use of the basement in this manner secures service from a portion of the building which otherwise is likely to be used for storage only, and also, that an equal amount of space is obtained on the upper floors for classrooms. On the basis of economy and seclusion, the main basement toilet room is desirable, but this is the only recommendation which the writer has ever found for it. The basement toilet is neither accessible nor convenient; it is quite likely to be poorly lighted, and, owing to its distance from occupied rooms, its ventilation is often neglected.

It is encouraging to note that the better new schools, especially high schools, are being equipped with toilet rooms for both sexes on every floor. This arrangement reduces the running up-and-down stairs to a minimum and prevents the congregation of large groups of pupils in a room where they are not under the teachers' supervision. The arrangement, also splits up the congestion of a large number of fixtures into six or eight sub-divisions, each located in a separate room with an outside window, thus securing ventilation and light in an amount vastly superior to that possible in the basement.

The number of fixtures required for any given school is governed entirely by the number and the age of the occupants. It is probably conservative to say that about 20 per cent greater toilet accommodations should be furnished in a

grade school, embracing the classes from kindergarten up to the eighth grade, than in a high school in which the average age is from 15 to 16 years.

Regarding the number of fixtures, it is interesting to note the table (Fig. 71), in which five high schools, "HS," and three grammar schools, "GS," all recently completed and placed in service, are listed in a comparison of the number of plumbing fixtures installed. The second vertical column gives the number of pupils for which each building is designed; the third column, "WC," indicates the number of water closets in the building, and the fourth column, "per cent," indicates the number of water closets per one hundred pupils. Thus we see that in High School No. 1, designed for 1050 pupils, there are 56 closets installed, or 5.33 closets per one hundred pupils. In High School No. 2, designed for 1150 pupils, the accommodations are not nearly so great, there being 34 closets in all or 2.95 per one hundred pupils. High School No. 1 is undoubtedly somewhat high (altho not excessively so) while High School No. 2 is likely to experience difficulty with its toilet accommodations.

High Schools 3 and 4 may be assumed as being nearer the average, these having 4.58 and 3.67 for closets per one hundred students. High School No. 5, built for 1800 pupils, has a much higher percentage of toilet accommodation per pupil thruout, owing to the fact that this building carries a large department known as the "Shop Section" for manual training consisting of carpentry, forge work, bench shop, wood turning, etc. All of the shops are on a separate floor and accommodations are provided on the same level, thus to some extent duplicating fixtures installed on other floors.

In the three grade schools listed, the water closet accommodations are higher than in any of the high schools cited, this being entirely consistent and accounted for by the presence of a large number of very small children.

The fifth column, "U," gives the number of urinals installed in each school. It is estimated that every running two feet of a trough urinal are counted as a single fixture. It is apparent that a fairly good balance is maintained in both

the high schools and grammar schools in proportioning these fixtures, few varying greatly from the average of 1.79 per one hundred pupils.

In the seventh column "L" are listed the lavatories, which in High School No. 5 reach an excessive figure owing to the large shop section previously mentioned. The ninth column "DWF," shows the number of drinking water fountains installed, High School No. 5 being excessive on this point also. Probably 1.5 fountains per one hundred pupils can be considered a very conservative and satisfactory figure.

instead of the number of pupils served, and it reconciles to a great extent, apparent inconsistencies shown in the first table. For instance, High School No. 5 (owing to its large size to accommodate the shop section) in the second table figures low on both its closet and urinal accommodations. It is still a little high on lavatories, but even there it does not exceed Grammar School No. 3, drinking water fountains being the only fixtures which show in excess in both tables.

The percentage of fixtures to cubic contents in Fig. 72 is figured on the basis of 100,000 cu.

CASE	PUPILS	WC	%	U	%	L	%	DWF	%	SS	%
HS #1	1050	56	5.33	23	2.19	40	3.81	8	.75	8	.75
HS #2	1150	34	2.95	17	1.47	26	2.26	6	.52	3	.26
HS #3	1200	55	4.58	24	2.00	35	2.92	14	1.16	8	.66
HS #4	1500	55	3.67	22½	1.50	45	3.00	10	.67	8	.53
HS #5	1800	94	5.22	33	1.83	184	10.22	84	4.66	20	1.11
GS #1	550	35	6.03	12	2.18	10	1.82	6	1.09	3	.54
GS #2	700	51	7.29	11	1.57	39	5.57	9	1.29	4	.57
GS #3	700	46	6.57	13	1.86	45	6.43	8	1.14	5	.71
Total & Av.	8650	426	4.92	155½	1.79	424	4.90	145	1.68	59	.68

Fig. 71.

CASE	CUBAGE	WC	%	U	%	L	%	DWF	%	SS	%
HS #1	2,000,000	56	2.80	23	1.15	40	2.00	8	.40	8	.40
HS #2	1,100,000	34	3.09	17	1.54	26	2.36	6	.54	3	.27
HS #3	1,660,000	55	3.31	24	1.44	35	2.11	14	.84	8	.48
HS #4	2,125,000	55	2.59	22½	1.01	45	2.11	10	.46	8	.38
HS #5	4,500,000	94	2.09	33	.73	184	4.09	84	1.87	20	.44
GS #1	500,000	35	7.00	12	2.40	10	2.00	6	1.20	3	.60
GS #2	1,070,000	51	4.79	11	1.03	39	3.64	9	.84	4	.38
GS #3	1,055,000	46	4.36	13	1.23	45	4.27	8	.75	5	.47
Total & Av.	14,010,000	426	3.03	155½	1.11	424	3.03	145	1.03	59	.42

Fig. 72.

The second last column, "SS," shows the number of slop sinks installed, High School No. 5 being apparently liberal on this point also. The number of slop sinks, however, is determined not so much by the number of pupils as by convenience of access by the janitor, the general practice being to place two upon each floor of a large school and one upon each floor of a small school.

The table just discussed is based entirely upon the relation which the number of fixtures should bear to the number of pupils served. This proportion, as previously stated, is the only proper method of estimating the number of fixtures required. As a check upon this, the table shown in Fig. No. 72 is also very interesting. This table is worked out exactly the same as the previous table with the exception that it is based upon the cubic feet contained in the building

ft. so that a percentage of 2.80 water closets means that there are 2.8 closets for every hundred thousand cubic feet contained in the building. Any new school checked with the average of these two tables should give a high and low number of fixtures which may be used as practical boundaries. Fixtures installed somewhere between these two limits will be sufficient to give practical service and yet will not be excessive. Their location on the different floor levels should to a large extent be determined by the proportion of pupils located on the respective floors.

If it is absolutely necessary to install the main toilet room in the basement an arrangement such as indicated in Fig. 73 is probably one of the best layouts which can be secured, altho even the best cannot be recommended. In this scheme the boys come down a stairway at one end of the building into a boys' corridor to the

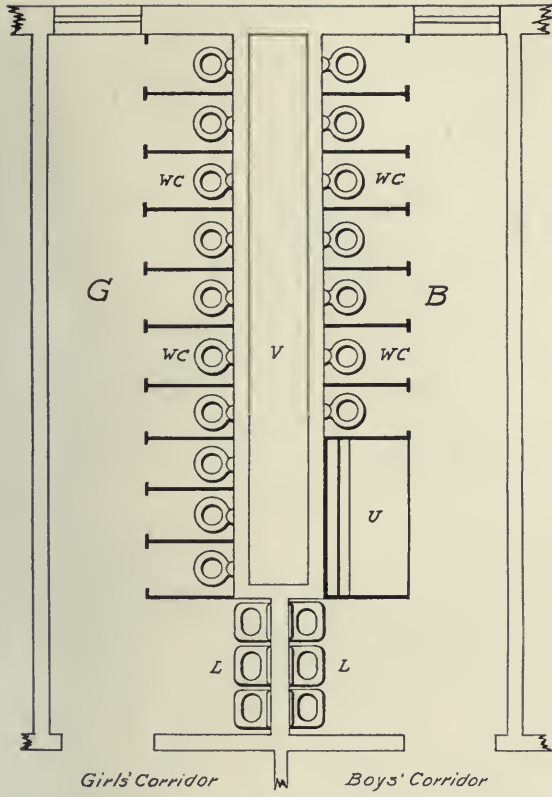


Fig. 73.

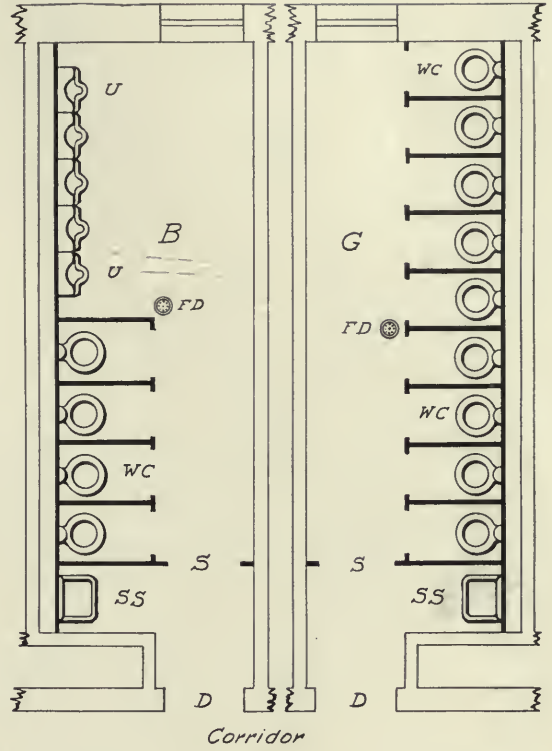


Fig. 75.

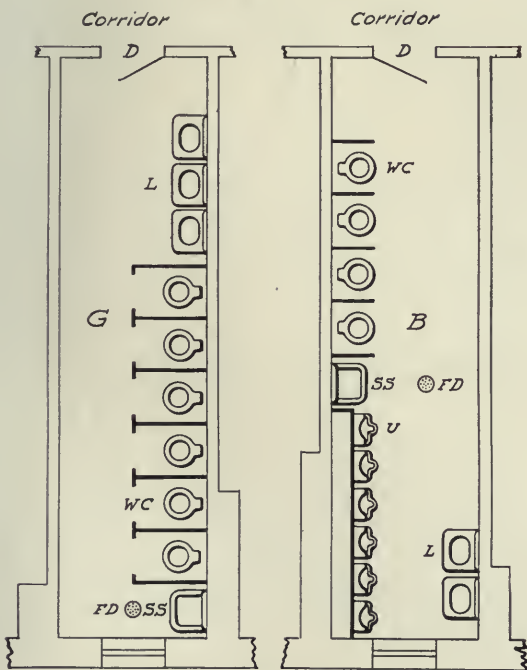


Fig. 74

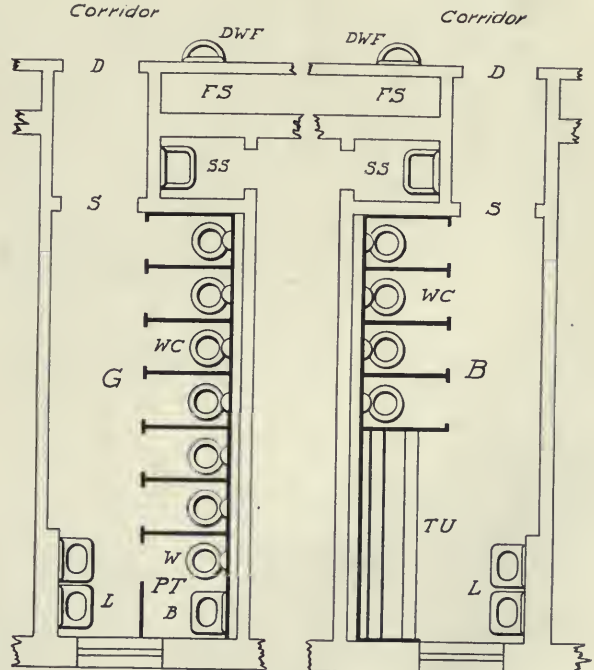


Fig. 76.

main toilet room. This should be somewhere near the middle of the building. The girls follow a similar procedure at the other end, but there is a solid partition at the toilet room separating the boys' corridor from the girls' corridor and effectually preventing any conflict between the sexes below the first floor.

The fixtures should be arranged on each side of a vent space *V* in which all valves and piping can be located, the girls' fixtures in the girls' toilet room *G* backing up against one side of this vent space, and the boys' fixtures in the boys' toilet room *B* backing up against the other side. If desired the vent space *V* can be continued to the corridor wall with an access door for repairs.

In all the toilet rooms shown with this chapter *WC* indicates water closets, *U* urinals, *L* lavatories, *SS* slop sinks, *DWF* drinking fountains and *FD* floor drains.

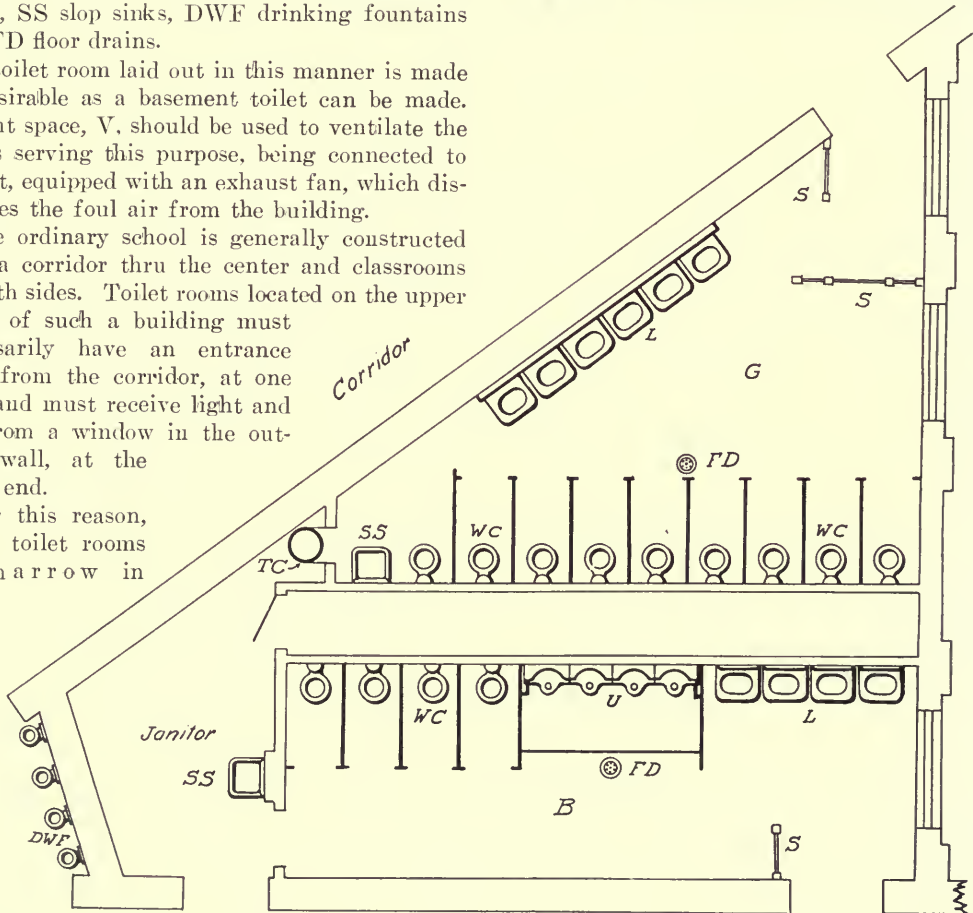
A toilet room laid out in this manner is made as desirable as a basement toilet can be made. A vent space, *V*, should be used to ventilate the rooms serving this purpose, being connected to a duct, equipped with an exhaust fan, which discharges the foul air from the building.

The ordinary school is generally constructed with a corridor thru the center and classrooms on both sides. Toilet rooms located on the upper floors of such a building must necessarily have an entrance door from the corridor, at one end, and must receive light and air from a window in the outside wall, at the other end.

For this reason, many toilet rooms are narrow in

width but are equal in length to the width of the ordinary classroom.

Two toilet rooms built in this shape are shown in Fig. 74; *G* indicates the girls' toilet room, *B* the boys' toilet room, and *D* the door. The rooms are located at opposite ends of the main corridor and have entrances directly therefrom. The rooms are repeated on each floor level of the building. Several criticisms can be made in this arrangement, first of which is the fact that no screen is present to prevent the passerby in the corridor from obtaining a full view of the toilet room whenever the door is opened. Second, the slop sink, in case of the girls' toilet room, is located as far from the door as it could be, instead of close to the door for the convenience of the janitor. In fact, the slop sink should not be placed in a toilet room but should be located



Corridor
Fig. 77.

in its own closet. This will be shown in other layouts which are much more satisfactory.

In Fig. 75 we have another similar toilet room in which the slop sink is placed in a much more desirable position and where the screens S, which are equipped with swinging doors, effectually shut out observation when the corridor door, D, is open. The school, however, has made a serious error in the omission of lavatories from the toilet room. These should never be omitted; at least one or two are necessary in all cases.

In Fig. 76 are shown much better rooms of this type. These two toilets have the following desirable points: The opening of the door D is screened by a second door S; the lavatories L are located near the window; a private toilet, PT, is installed in the girls' toilet room, G; and, the slop sink, SS, is placed in its own closet where it can be reached by the janitor without entering the toilet room. Immediately outside the toilet room in the main corridor, drinking water fountains, DWF, are hung, and the space behind the fountains, FS, is used for ventilating flues. It

is to be regretted that in this school where the toilet facilities have been well taken care of the use of the trough urinal, TU, should have been allowed.

In Fig. 77 is shown a combined toilet room which, however is possible only in schools where more than one main corridor exists. In this particular case one wing of the building runs at an angle to the main portion producing an angular main corridor as shown. On the angular corridor, entrance to the girls' toilet room, G, is obtained thru a door screened by the two screens, S. A private toilet is placed in the end of the room; here also is a towel chute TC. In the boys' toilet room, B, a screen, S, and individual urinal fixtures are also provided. The janitor has his own closet with a slop sink, this closet being large enough in which to do considerable washing and cleaning, if necessary. There is absolutely no criticism to make in the arrangement of fixtures in this toilet room, and it is regretted that the layout is not such as to make it applicable to schools in general.

CHAPTER VIII

Toilet Partitions—Shower Baths

The matter of partitions in toilet rooms is a most important one and should be given careful consideration by every school board. These partitions ought to be non-absorbent, substantial, pleasing in appearance, and should be built with the least possible amount of metal work. Formerly and even at the present time slate is much used, altho alberene stone has of late years been widely adopted. Marble is seldom, if ever used, in school work owing to the expense, while Argentine glass undoubtedly produces the finest kind of result.

Argentine glass is milk-white and non-transparent. It is produced in sheets about one inch thick, and gives an inviting and sanitary appearance attained by no other material. This glass, of course, will not stand so much hard usage as other materials and it is therefore impracticable to build partitions of it except where a reasonable amount of care may be expected. For instance, Argentine glass partitions may be used in high schools but never in grammar schools.

Where alberene stone is employed it is cut in slabs one inch or one and a quarter inches thick, is polished and made up with rabbetted joints. The alberene partition is of a grayish color with long black veins which are likely to extend thru portions of the stone. These veins give the appearance of weakness with danger of possible future cracks; but this danger is confined to appearance only, as the stone is at least as strong—if not stronger—at the veins than in the clear material.

Slate, the old standard material, requires little argument or explanation owing to its extensive use. Almost every school employs slate partitions to a greater or lesser extent. The chief objection—if it is an objection—to slate, is the appearance which is dark and uninviting. Slate partitions also offer much opportunity for scratching and for marking objectionable pictures and writing on the toilet room walls. This latter, of course, is highly undesirable.

One school board has, after much experimentation, adopted the slate partition *painted white*, and provides each janitor with a can of quick

drying white paint. Every day at the close of the school session the partitions and walls are inspected and all writings are disposed of in a moment by a little white paint. This paint becomes dry before the beginning of the school session the next morning.

The normal water closet enclosure which is shown in Fig. 78 should be about 4 ft. or 4 ft. 6 in. deep, 6 ft. 6 in. high and should have the back set out 6 in. from the wall to conceal the piping and also to serve as vent space. While the backs of the enclosure should extend solid to the floor, the partitions between the enclosures should be supported 12 in. above the floor, to permit the free circulation of air about and around the fixtures. The partition slabs are usually supported by angle clips and by being set into the back slab, while at the front iron or brass standards are used. The standards generally extend down and are embedded in the floor.

The wainscot is usually made of the same material as the partitions and compartments, altho sometimes a tile wainscot is used. This should extend the same height, namely 6 ft. 6 in. above the floor. It is usually provided with a small cap piece for a finish. In Fig. 79 a view is shown of the same type of compartments (looking the other way) indicating the most satisfactory method of ventilating a toilet room, namely, thru a register R placed back of the water closet. This does away with all discussion as to the sanitary or insanitary qualities of the local vent closet and secures equal or possibly superior ventilation results.

Let me call attention to a danger which seems to be on the increase. This is the instilling into the younger generation of what might be termed a "lack of decency" for which some boards are almost criminally responsible. It is not believed that any member of any modern school board would install a water closet in his own home in an open hall without screens where members of the family are constantly passing back and forth. Yet in the school, toilet rooms (in which a constant promenade is going back and forth) are often provided with fixtures—

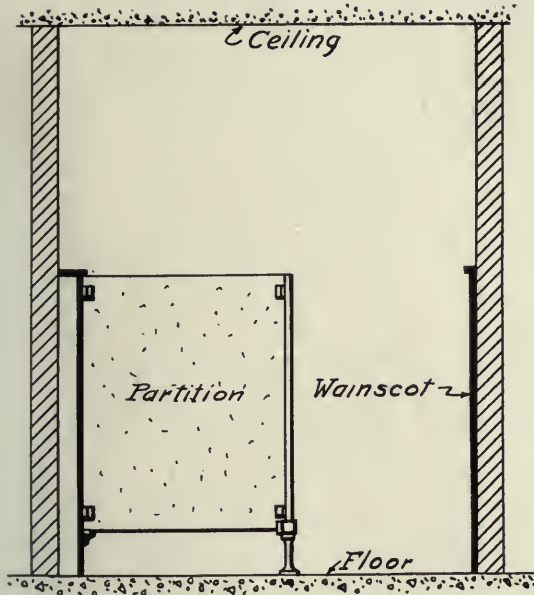


Fig. 78.

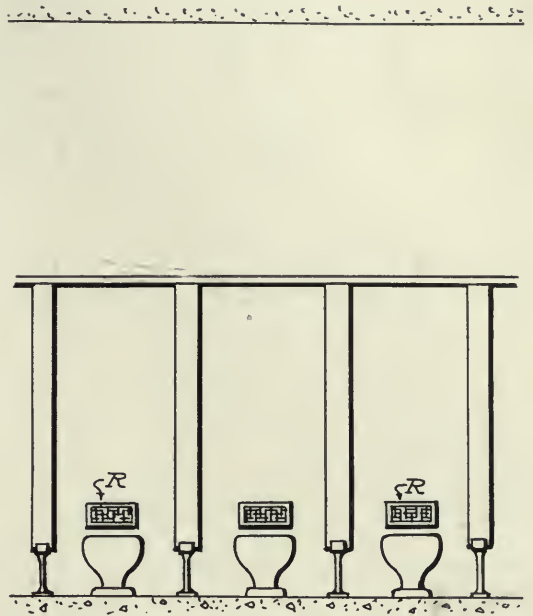


Fig. 79.

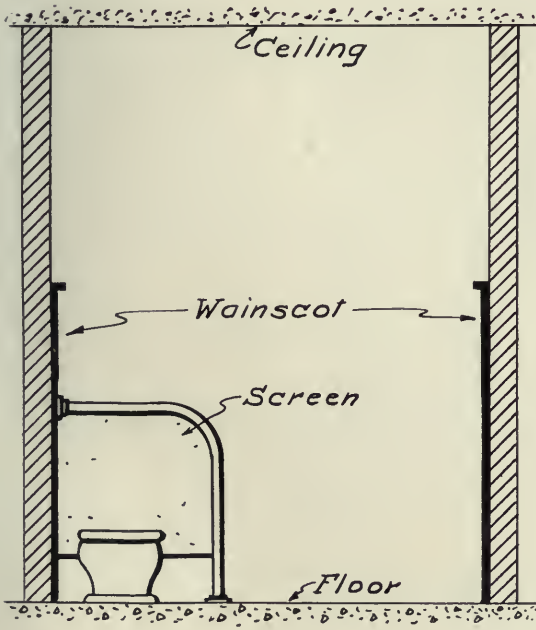


Fig. 80.

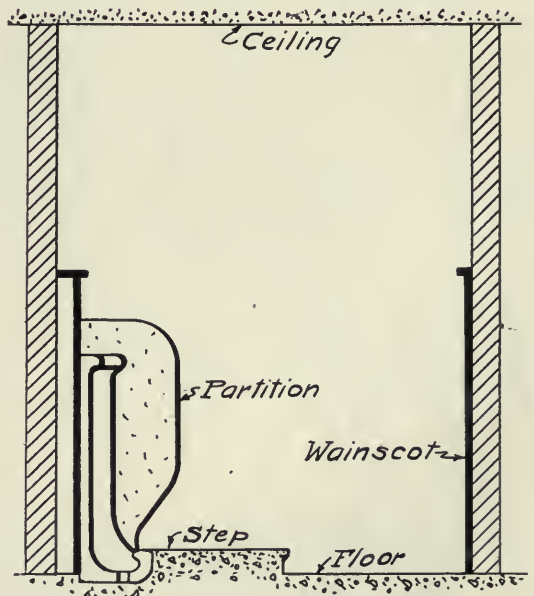


Fig. 81.

possibly with screens between them—without doors and provocative of a lack of modesty which is far from what parents desire.

As an example of this we have toilet rooms in many schools built somewhat on the scheme shown in Fig. 80 in which a simple dividing screen, made of sheet iron and supported on a piece of bent pipe, is used to avoid the expense of a proper closet partition. Arguments in favor of this arrangement can be heard on the basis of economy, better circulation of air, increased light, etc., etc. But after all advantages have been duly weighed, the fact cannot be overcome that water closets installed in this manner should be considered a nuisance by the community, and the board responsible for such an installation should be severely censured.

It should be remembered that, where a pupil is required by law to attend school a certain number of hours a day, he or she must of necessity use the toilet fixtures provided by the school board and that the board, in failing to provide suitable enclosures, indirectly forces a pupil, willingly or unwillingly, to use the facilities provided. Under such a condition of affairs school boards should be doubly careful in the arrangement of toilet rooms and the manner in which they are fitted up.

This subject brings up another. It was formerly the custom to omit partitions entirely on all types of urinals, yet it is encouraging to note that the use of a slab partition between the fixtures as shown in Fig. 81 and the dividing off of the trough urinal by similar partitions is gradually coming into practice. Fig. 81 is a good example of individual fixtures, properly partitioned, with a vent space in the rear into which an integral local vent from the fixtures, or a local vent from the pipe below the fixtures, can be connected.

Shower bath stalls are built in three ways. The first is the individual shower bath stall as shown in Fig. 82. This stall is about 3 ft. square and 6 ft. 6 in. high. The walls are carried down to the floor slab on all sides and the doorway is cut down to within 6 in. of the floor, the 6 in. below this point serving as a curb to retain the splashing water. The top of the doorway is formed by a rod which serves as a brace for the slabs, and from which the curtain is hung by rings.

The second type of shower bath is that com-

bined with the dressing room as shown in Fig. 83. This consists of a shower bath compartment as just described, the compartment in this case, however, opening into a dressing room of similar size. A curtain is used between the dressing room and shower and a dwarf door, similar to a water closet door as shown, is used to screen the dressing room. In many cases it has been found desirable to cover the tops of compartments with a wire screen, as indicated in the drawing, to prevent the stealing of clothes, towels, etc., by pupils in the adjacent compartments, and to prevent skylarking and the throwing of missiles into the compartments when they are occupied. Care should be taken in an arrangement of this kind to leave sufficient room under the dwarf door so that in case of emergency access to the interior can be had by the instructor by crawling under the door and unlocking the same. Several cases have been known where persons have been taken suddenly ill or have fainted while using a shower thus requiring immediate attention and outside help.

The third type of shower is shown in Fig. 84. This consists of a shower compartment as

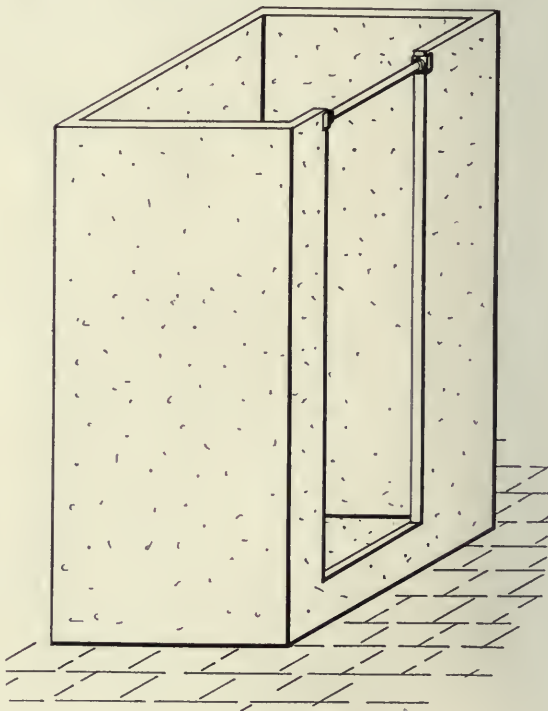


Fig. 82.

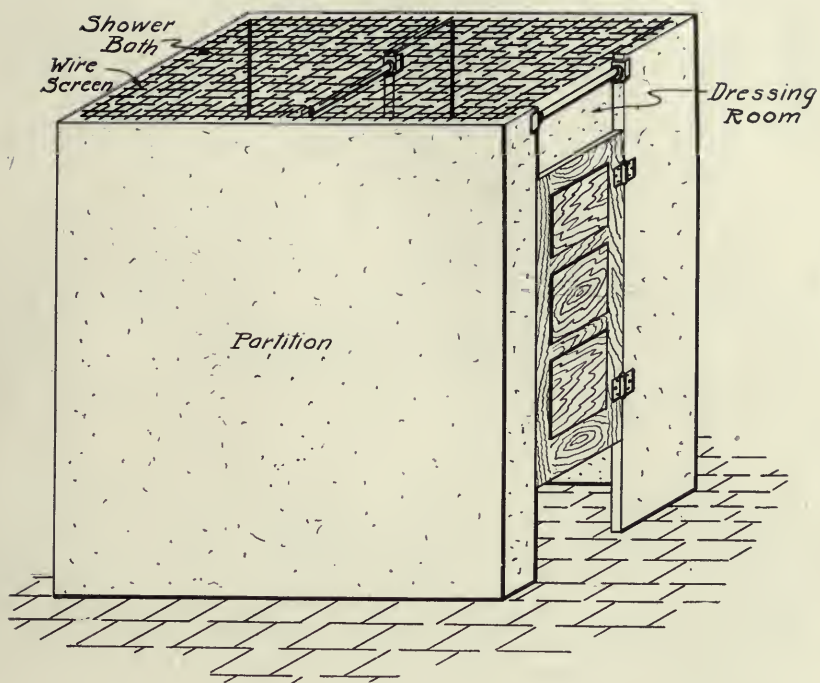


Fig. 83.

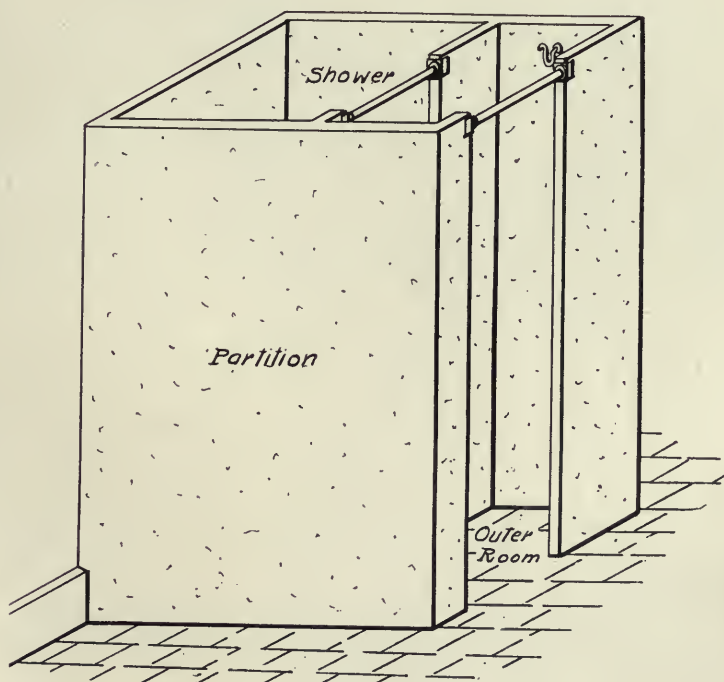


Fig. 84.

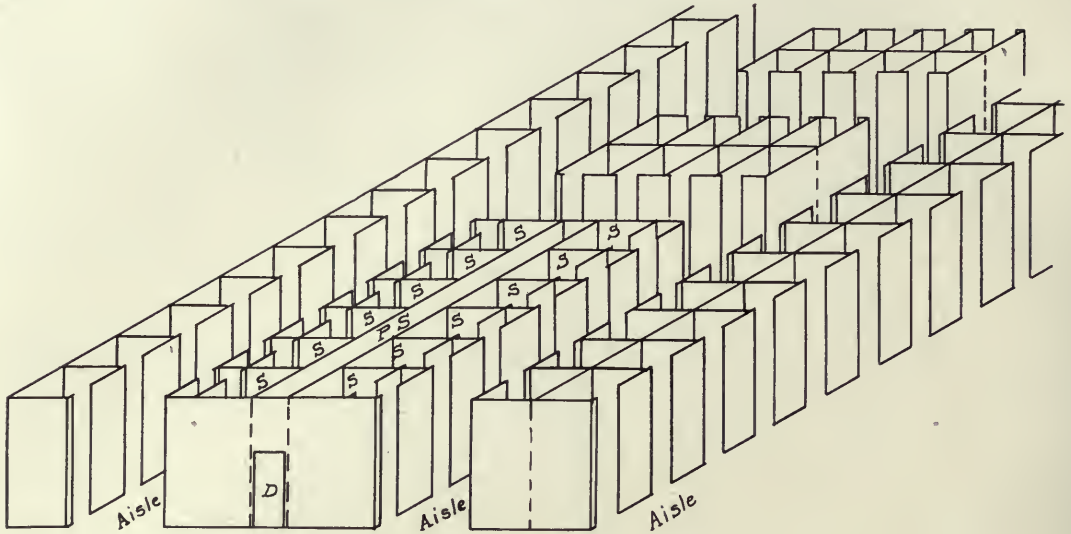


Fig. 85.

previously described and an outer room 18 to 24 inches wide in which a hook is placed. The purpose of this outer room is to keep dry a sheet or dressing gown, bath slippers and bath towel. Showers arranged in this manner are generally used in connection with a girls' locker room. The arrangement is somewhat as shown in Fig. 85, where S indicates the showers and outer rooms, the unmarked compartments are dressing rooms; P. S. is a pipe space, between the two rows of shower baths, and D an access door for repairs. In a scheme of this kind each girl pupil is assigned a dressing room in which she removes her outer clothing preparatory to the use of the shower. Sheets are usually provided by the school to be worn in passing from the dressing room to the shower bath, altho some pupils prefer to use a bathrobe or dressing gown. It will be seen from Fig. 85 that while some of the dressing rooms are very convenient to the showers others are at a considerable distance.

The method of procedure for the pupils is briefly as follows: Wrapped in sheets and wearing slippers, the girls pass from their individual dressing rooms to the outer rooms of the showers. These outer rooms may be protected by a curtain or a dwarf door similar to the one previously shown. The towels, sheets or gowns and slippers are placed in the outer rooms and the shower baths taken in the adjacent shower compartments, curtains being placed between

the outer rooms and the showers in order to keep the articles in the outer rooms dry. On completion of the bath the pupils dry themselves in the shower compartments, step into the outer rooms, don slippers and sheets or robes and return to the dressing rooms to complete their dressing.

There are great advantages with this arrangement involving as it does a minimum time in the shower and making fewer showers serve a larger number of pupils satisfactorily. It allows the showers to be placed closely together, simplifies and economizes the plumbing, and above all allows the pupil the privacy which all are justified in demanding.

The metal work for partitions should be kept down to the smallest possible amount. Such as must be used is generally made to correspond with the fixture trimmings. Nickel plated brass is more commonly used than any other one material, yet it is far from being satisfactory for continued service. The nickel—if polished—soon wears off and, if not polished, gets dirty and becomes covered with verdigris caused by the splashing water which combines with the copper in the brass body underneath.

Polished brass is used to some extent, this material being of solid metal and always of the same standard appearance when kept polished. It is cheaper than nickel plated material.

Red metal is brass with an unusually high

amount of copper in the composition (85 per cent or more); this is being adopted in some of the newer schools.

White metal is by far the most satisfactory of all the various materials, but it is also much higher in cost. It is a metallic composition which has exactly the appearance of nickel plate,

but is liable to tarnish less quickly. Its use is recommended wherever financial considerations permit. Sometimes economy can be effected by using galvanized cast iron piping underneath the lavatories and painting same with white enamel to match the color of the fixture.



GIRLS' SHOWER ROOM IN A NEW ENGLAND SCHOOL.

CHAPTER IX

Water Supply Systems

There is little of greater importance in the modern school than an adequate supply of clean and pure water at a cost not so high as to be excessive. In some districts where schools are erected a good municipal or private company water system in service with reasonable rates and pressure solves the difficulty, but in other cases conditions must be met which involve calculations based on the height of the building, probable amount of water used yearly, cost of water per cubic foot, cost of coal, and interest on pumping equipment. It is not at all impossible that it may prove cheaper to drive a well on the premises and pump all water used than it would be to buy the supply from a local corporation.

A water supply may require special attention from any one of the following reasons:

- (a) No supply of any kind available.
- (b) Proper water but insufficient pressure.
- (c) Proper water but too high pressure.
- (d) Proper water but with great fluctuation in pressure.
- (e) Water not fit for use without purification.
- (f) Water supply not to be depended upon at all times.
- (g) Any combination of the above.

Where no water supply is available a driven well and pump are the usual recourse. In this case the water is either pumped into an elevated tank (maintaining the proper pressure on the school by gravity), or it is pumped into a so-called "pneumatic" tank in which compressed air is confined, the pressure of the compressed

air tending to drive the water out of the tank when a faucet is opened and thus keeping the building under proper pressure.

A typical pneumatic system recently installed in one of the new high schools is shown in Fig. 86, being arranged as shown diagrammatically in Fig. 87. Here the pneumatic tank T with a manhole Mh and supported on the piers P is filled by the water pump WP driven by the motor M. The operation of this apparatus is entirely automatic being controlled by the regulator R which operates the electric switch S controlling the wires W to the motor M. The water from the pump is discharged past the air cushion AC, the air supply being maintained in the tank by the use of the little belted air compressor C. This compressor is a necessary adjunct to all pneumatic systems as the air in the tank, when under pressure and in contact with the water, becomes entrained in the water in the form of minute bubbles. This process results, of course, in gradually withdrawing the air from the tank making necessary some means of renewal. The bubbles give the water a peculiar milklike appearance when drawn at the faucet.

With an elevated gravity tank several difficulties and objections are likely to arise. In the first place it must be supported—no mean proposition when it is considered that a 5,000 to 10,000 gallon tank (customary size for schools) weighs from 45,000 to 90,000 pounds or an average of 33 tons! This tank must be placed on a floor at least one story above the

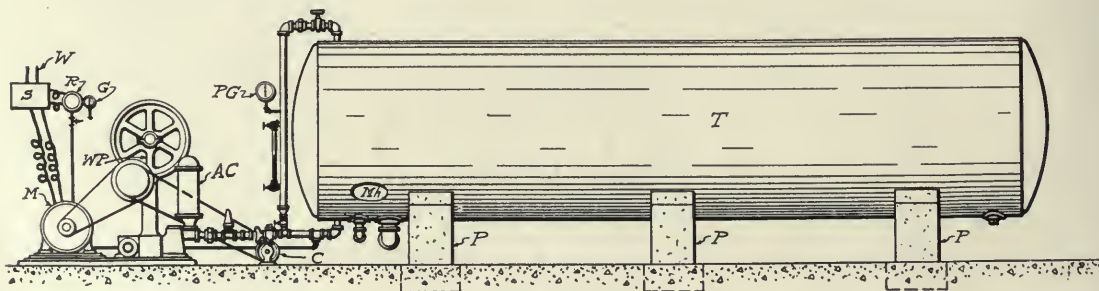


Fig. 87



Fig. 86. Pneumatic Tank in a New School.

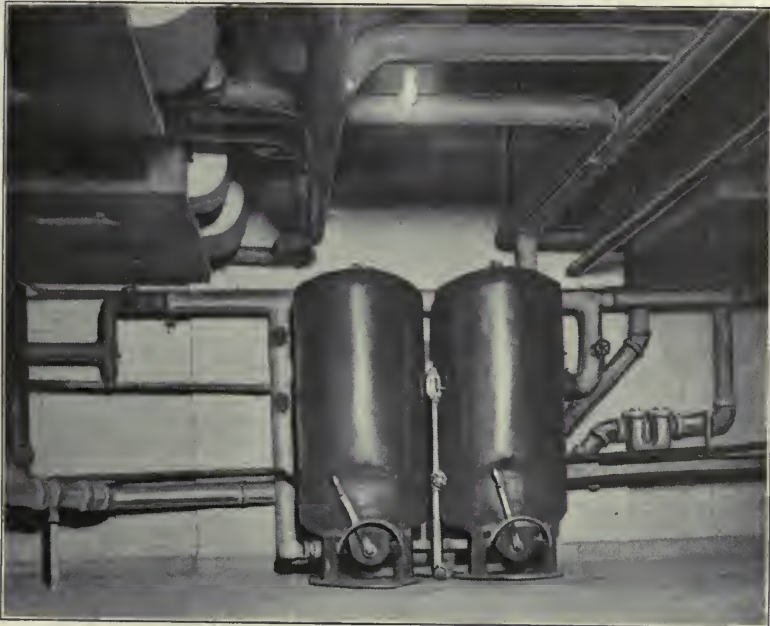


Fig. 88. Drinking Water Filters of Good Type.

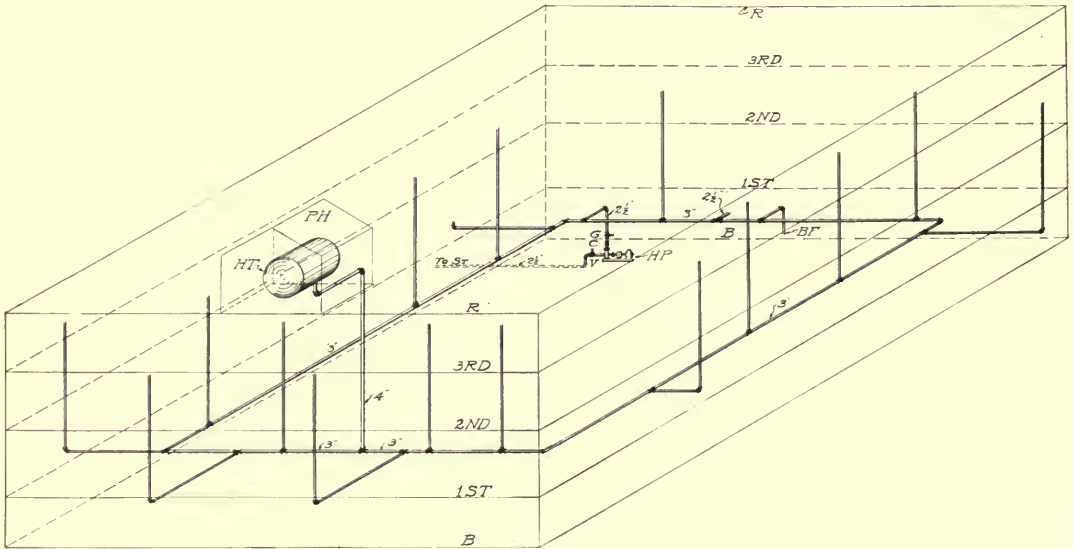


Fig. 90.

floor on which the highest fixture stands in order to get sufficient pressure on the uppermost fixtures. The tank should be housed in and covered to keep it clear of dust and dirt; it must be protected against freezing, and after all these matters are attended to it will still allow the water therein to become warm or tepid in hot weather.

A pneumatic tank can be buried in the ground so as to keep the water supply fairly cold and

(with the possible exception of an objection to carrying a tank at such high pressure in the basement of the school) it is undoubtedly more satisfactory and certainly cheaper than an elevated gravity tank.

When water at too high a pressure is encountered a reducing valve must be used. Water delivered at more than 75 pounds pressure is objectionable to use. It produces leaks readily, and wears out faucets because they must be

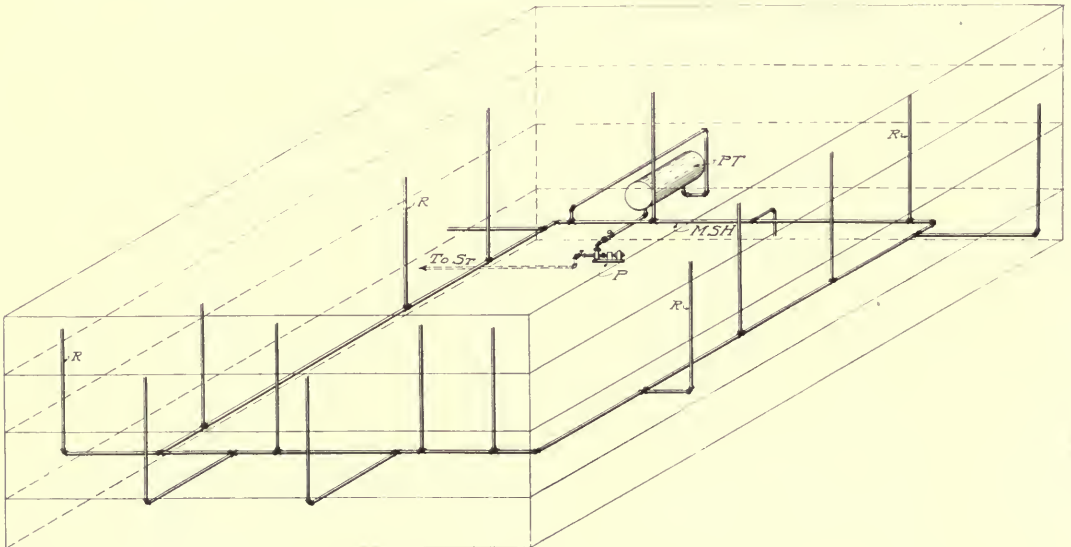


Fig. 91.

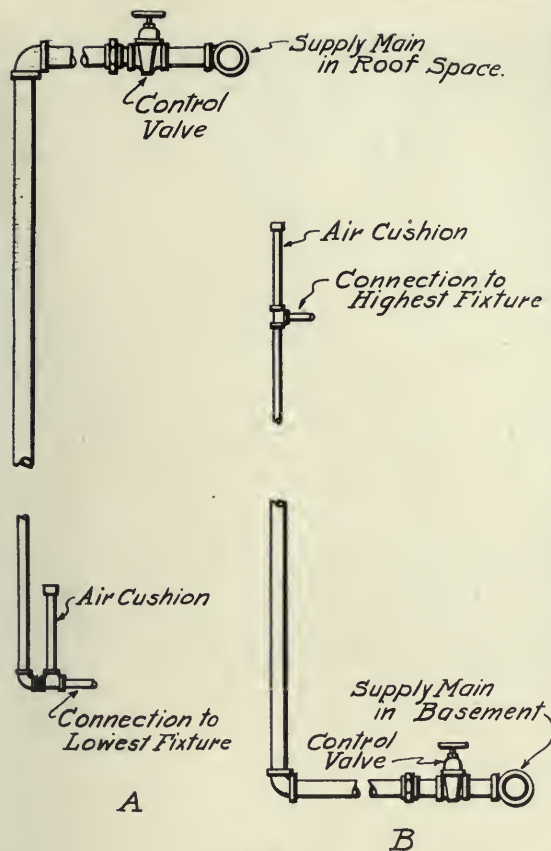


Fig. 92.

turned off tightly; it makes more frequent the renewal of faucet washers and produces "hammering" and undesirable splashing when the faucets are opened. In fact, 45 pounds per square inch pressure in the basement is a very good figure to carry. Reducing valves can be obtained for almost any desired reduction of pressure, the usual reduction being from 80 to 150 pounds down to 45 to 70 pounds.

When great variations in pressure occur it is often most economical to use a gravity tank, allowing this to fill *without* pumping when the pressure is high and making it large enough to carry the school until the next period of high pressure at which time it will be re-filled. If the pressure even at the highest point is not sufficient to force the water up into the tank, then pumping must be resorted to and a pneumatic equipment will probably be more satisfactory.

Water is sometimes obtained which is sandy (for instance river water or lake water in time

of spring rains) or it may be contaminated by bacteria from various sources. Sand and grit are very undesirable as they get into flush valves, shower valves, etc., and clog their operation, besides cutting washers, lodging on valve seats and causing other annoyance. This trouble can be disposed of by use of pressure filters which employ sand, quartz, charcoal, and other mediums for filtration. The filters for a large sized school will cost from \$1,200 to \$1,500, if of the best make and materials. Cheaper filters can, of course, be had, but they are a poor economy in the long run.

For bacterial impurities, filters are also used altho not so efficiently. When water is driven thru a filter a sort of mat forms on the surface in which certain bacteriological processes are carried on resulting in partial purification, this purifying being further assisted by bone black or charcoal. The use of filters, in general, may be said to be at its best when confined solely to *clarifying* water—that is, removing substances floating or *not dissolved* in the water—since anything in solution is affected little, if any, by filtration. A double cylinder filter of the best type is shown in Fig. 88, this being arranged so that the water passes thru first one cylinder and then the other, thus giving really two separate filterings.

For sterilized water there are four standard processes—distillation and recondensing, boiling or raising to boiling point, chemical treatment and electrical treatment. Distillation produces water which, however pure it may be, is at the same time robbed of its salts, gases and other substances. The result is a flat and unpalatable—the pure—product.

By boiling or by just raising to the boiling point (which is better) water fairly free of bacteria can be obtained containing a large proportion of its original characteristics. This process has gained great favor. Electrical treat-

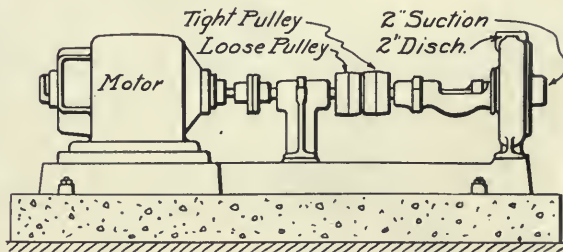


Fig. 93.

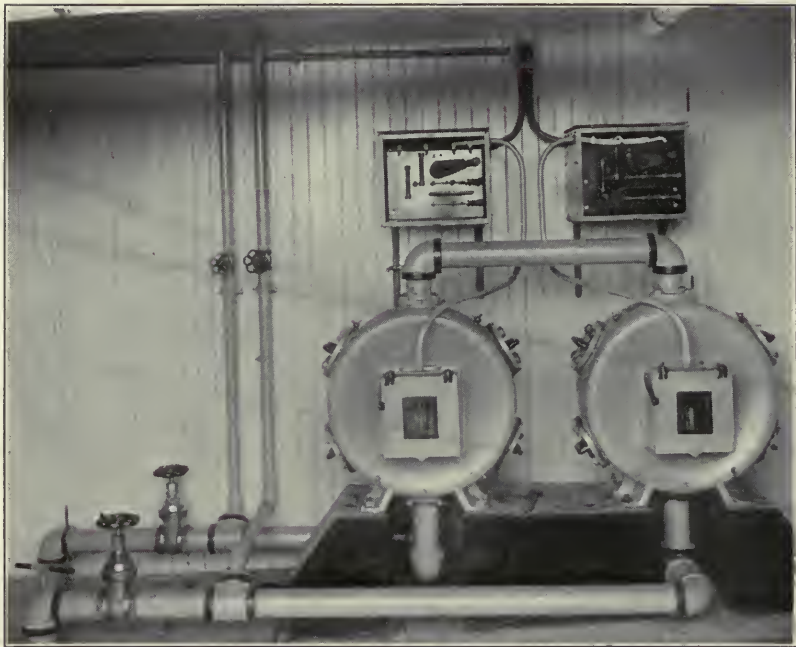


Fig. 89.

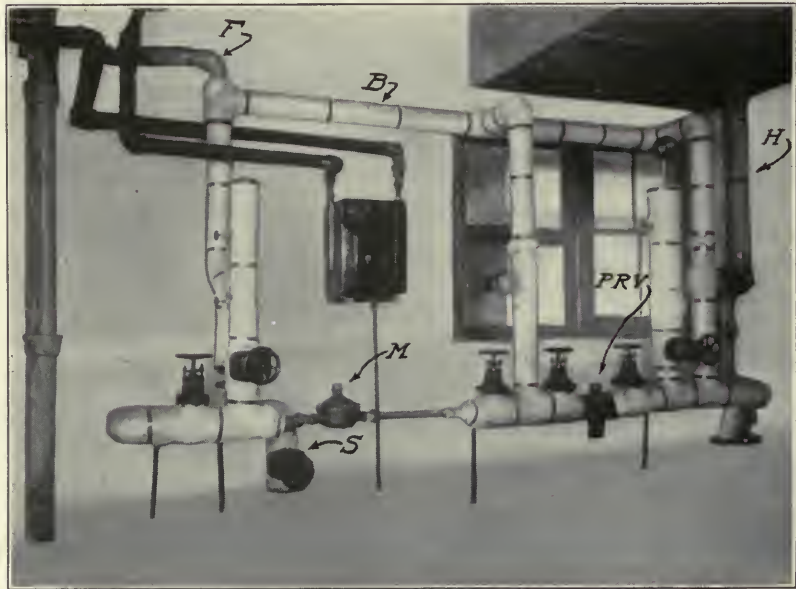


Fig. 95. Water Supply in School with Pressure Reducing Valve, Temporary Meter, By-pass, Etc.

ment by means of ultra-violet rays produced by a special electric lamp in a crystal bulb is more expensive but at the same time more satisfactory than any of the other methods. Positively no change whatsoever is made in the water or its taste but the bacteria are absolutely killed within a fraction of a second after exposure to the ultra-violet rays. To make this system practical the water must be clear. It may prove necessary, however, in some cases to install filters in conjunction with the electric sterilizer. A view of an ultra-violet ray sterilizer installed in the Bennett School, Millbrook, N. Y., is shown in Fig. 89.

If for any reason, a roof tank or "house" tank is decided upon, it will be more economical to put the main water pipe in the ceiling, or roof space, over the top floor. This is, of course, provided the construction of the building permits; if there is no such space the entire water supply must be carried down and fed from the basement as shown in Fig. 90. This illustration is an oblique projection of an ordinary school system arranged with a house tank HT in the pent house PH and supplying risers thru a basement main as just described; the pump HP is used in this case to fill the house tank thru the check valve C and gate valve G when required. Fig. 91 is a view of a similar system assuming that a pneumatic tank is used (located in the basement as shown). In this case the risers R are fed from the main supply header MSH located in the basement and supplied by water under pressure in the pneumatic tank PT. The water is pumped into the pneumatic tank by the pump P.

With the roof space, or "top feed," system the pipe risers are arranged as shown at "A," Fig. 92; but with a basement, or "bottom feed," the vertical pipes are arranged as shown at "B." The valves allow repairs to be made on any riser without interfering with any other fixtures except the ones located on that particular riser.

Undoubtedly the best type of water pump (not a *well* pump) for schools is a little direct connected, motor driven, centrifugal pump such as is shown in Fig. 93. A pump of this kind does not require packing, has no pulsation (when starting up it gradually builds up a pressure until it exceeds the back pressure of the discharge pipe) and has only one moving part—an interior rotating paddle wheel or impeller which is simply a plain iron or steel casting.

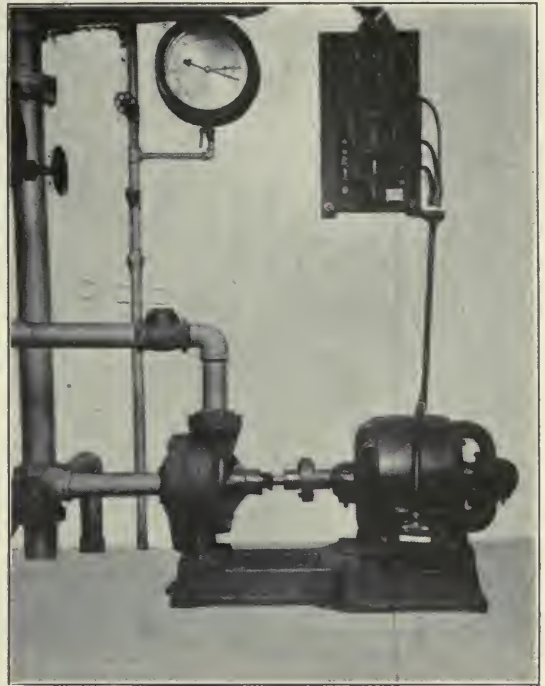


Fig. 94. Centrifugal Motor Driven "House Pump" with automatic control and pressure gage.

The pump shown has also a special tight and loose pulley to allow belt drive after disconnecting from the motor if at any time the current is cut off. The belt can be driven by a gas engine, hot air or steam engine or other mechanical means which local conditions permit. Provided the motor is of direct current type the tight and loose pulleys can be omitted, and an electric storage battery can be used to supply current to the motor. A storage battery will cost considerably more than a gas or steam engine drive even tho the latter may not be quite so convenient. A view of such a pump, actually installed with automatic control and pressure gage, is shown in Fig. 94.

Care should be exercised not to be deceived on water pressure. For instance, a school is proposed on a site where the minimum street water pressure is 35 pounds, and the highest 60 pounds. This means about 35 pounds in the basement of the school at least with a possible 60 pounds at certain times. Suppose it is expected to use filters and compression tank water closets with some of the closets located on the

third floor. Let us see if the pressure is sufficient:

Compression closets require 15 pounds to flush satisfactorily.

Three stories at 12 feet equals 36 feet by .43 pound equals $15\frac{1}{2}$ pounds loss for head.

Filter loss equals 5 pounds.

Pipe loss (friction) 5 pounds to 7 pounds.

Total loss, 15, $15\frac{1}{2}$, 5 and 5 to 7, or $40\frac{1}{2}$ to $42\frac{1}{2}$ pounds. This shows that part of the time the closets on the top floor would fail to operate properly.

A view taken in a newly completed school is

shown in Fig. 95. In this school it was necessary to reduce the water pressure for use, the street supply coming in at S, passing thru the temporary water meter M, the pressure reducing valve PRV and into the house line H. Either the meter or the pressure reducing valve (or both) can be cut out for repairs by closing valves on either side and opening valves on the by-pass B. The fire line is taken off at F so as to be subjected to the high pressure on the street side of the reducing valve. The temporary meter was installed for use during construction and will later be replaced with one of proper size.



TYPICAL SCHOOL SWIMMING POOL.

CHAPTER X

Hot Water Systems

The school of today should be provided with a hot water system which will supply hot water to all lavatories, shower baths, sinks and slop sinks. Before the introduction of showers provision for hot water was often omitted from schools, it being argued that the lavatories would answer their purposes reasonably well when supplied with cold water only. This was undoubtedly true. The introduction of showers, however, at once necessitates the installation of a certain amount of hot water equipment, together with the required piping. Under these conditions, it is a matter of only small additional expense to supply the other fixtures with hot water, making the system complete thruout.

To give satisfactory service in the modern school building, it is necessary for a hot water system to be installed so as to circulate hot water as closely as possible to the fixtures supplied. With the plain, "dead-end" hot water system, without circulation pipes, the water lies stagnant in the pipes and constantly cools off therein, making it necessary to draw off this cooled water thru the faucet outlet before hot water can be obtained. Where shower baths are installed the hot water piping is necessarily of fairly large size and this requires that a considerable body of water be thus drawn off.

To avoid this waste the circulating system is used, by means of which a constant circulation of water thru the hot water lines is maintained, this circulation extending up to the point where the "dead-end" or non-circulating branch to a fixture is connected to the main. To obtain hot water under these conditions, it is necessary to draw out only the small amount of water contained in the pipe between the faucet fixture and the circulation line, which (with careful designing) can be kept down to so small an amount as to make delivery of hot water almost immediate.

Circulation systems are of two kinds and are known respectively as the "downfeed" or "overhead system" and the "upfeed" or "basement" system. Of these two systems better results are obtained so far as circulation goes, with the overhead system. By this method it is neces-

sary to carry all of the hot water to the roof space above the top floor ceiling and then to feed (from this roof space) vertical hot water drops down and thru to the basement. Here the drops are collected together into a hot water return line which goes back to the hot water tank.

The cooling of the water as it stands in the drops causes it to contract thereby increasing its weight. The weight of the water in the main hot water riser carried up to the roof space is not thus affected. This results in the water in the drops sinking into the return line and going back to the tank as fast as it cools. It must be understood, however, that this cooling in a well designed system amounts to only ten or fifteen degrees so that even the return water is plenty hot enough for all ordinary use.

A graphic representation of a system of this kind is shown in Fig. 96 where the circulation system is used in connection with a house tank. The hot water heater is located in the basement B and is supplied from the house tank into which the cold water is pumped by a pump not shown in the sketch. From the hot water heater the water rises up thru the main hot water riser past the first, second and third floors to the roof space above the third floor ceiling C and below the roof R.

At this point (which is the highest point of the hot water system) an air vent pipe is tapped in, this being taken up into the pent house and turned down over the house tank. The reason for this is that all water when heated gives up a certain amount of air, ordinarily contained in all cold water), which collects in bubbles and gradually works to the highest point in the system. Of course when this air accumulates in any quantity it retards or stops entirely the hot water circulation.

The hot water supply then runs horizontally in this ceiling space so as to supply the required drops which are connected into the hot water return as shown. The probable method of running the cold water supply with the cold water drops paralleling the ones for hot water is also indicated.

In Fig. 97 is shown the up-feed system in which the main hot water supply, instead of being carried up to the space between C and R, is run in the basement and feeds the hot water supply risers from the bottom instead of from the top. The hot water ascends in these risers to a point just below the connection to the third floor fixtures at which point a branch is tapped off for the hot water return. This line parallels

be eliminated from consideration, especially where large quantities of water are to be heated.

The most common method of heating water is by means of a tank filled with the required amount of heating surface composed of brass tubing. In this tubing the steam is condensed the same as in an ordinary radiator. In fact, the brass tubes are nothing but pipe coils surrounded by water instead of air. A view of a

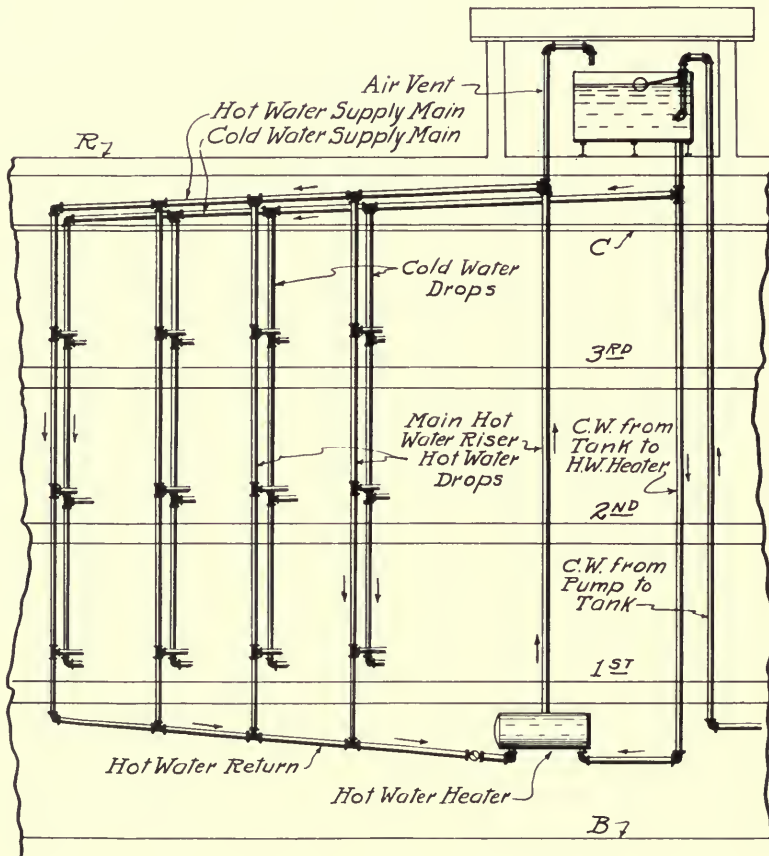


Fig. 96.

the riser down to the basement and is connected in the basement to the hot water return line, which is carried back to the heater. Air relief on this system is obtained thru the top fixture connections, the air being drawn off with the water as fast as it accumulates.

For heating water several methods are in use. Of these coal and steam are the cheapest and most used, and gas is next. The least common is electricity which is so expensive that it may

tank heater of that description is shown in Fig. 98. It is often desirable, however, to have heaters which can be used in the summer time when the main steam boilers are not in service. In a case of this kind the tank is installed as before but a hot water stove is also arranged to circulate water to and from the tank just as the ordinary kitchen stove circulates water to and from the kitchen boiler. This hot water stove is used when the main boilers are out of

service, but it is not used during the winter when steam is available. Exceptions are made of course in cases where the steam boilers are overloaded, and it is advisable to conserve the steam as much as possible by using the coal heater.

In cases of high water pressure, say 40 lbs. or over, it is not good practice to install hot water heaters (which are generally made of cast iron) as they are not built to stand any great pressure. In cases like this, instead of the small

In cases where showers are not installed, but where hot water is required only in small quantities, for washing dishes and for supplying a small number of lavatories, gas heaters are sometimes used. These gas heaters are automatic in operation and are arranged to keep the tank at a certain temperature. A thermostat in the tank turns on the gas (which ignites from a pilot light) whenever the temperature of the water falls below a certain number of degrees and turns off the gas (with the exception of the pilot

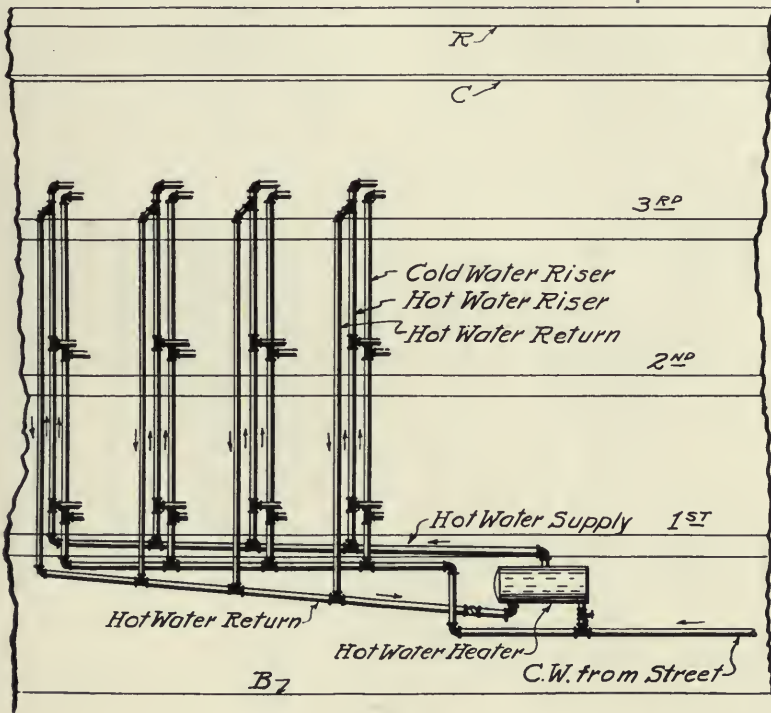


Fig. 97.

hot water heater, a steam boiler of equal capacity is installed. The steam and return connections are then run to the tank and cross connected to the supply and return connection from the building heating boilers. This results in filling the brass tubes with steam at all times, the steam coming from the small boiler during the summer and from the heating boilers during the winter. The plan avoids the use of high pressure on the cast iron boiler. A view of a hot water tank installed in one of the newest schools, in which both steam connections and a hot water stove are used, is shown in Fig. 99.

light) whenever the desired temperature is again reached. In many cases steam connections are made for winter service, especially when the water comes in very cold and the gas heater is installed for summer use only. A view of an installation of this type is shown in Fig. 100.

All hot water heaters should be provided with thermostatic control to prevent insufficient warming and overheating of the water. Without the attention of the janitor, overheating is apt to result in boiling and the formation of steam.

Where showers are installed special provision

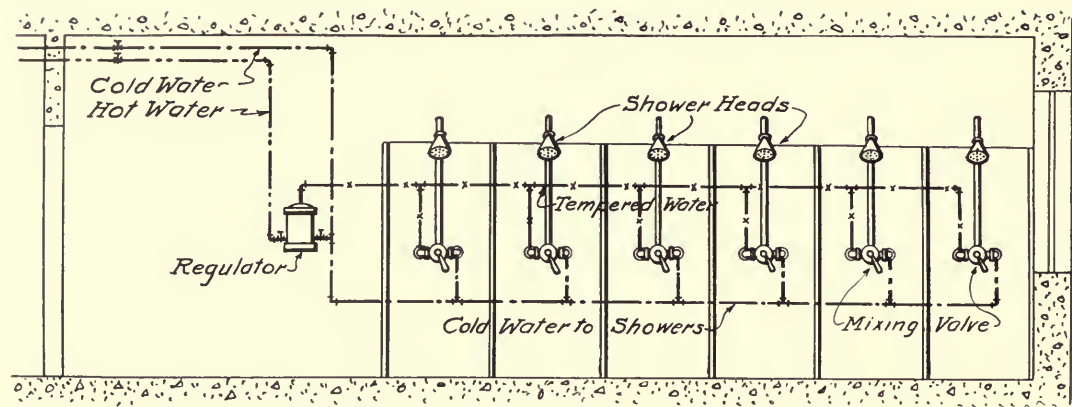


Fig. 101.

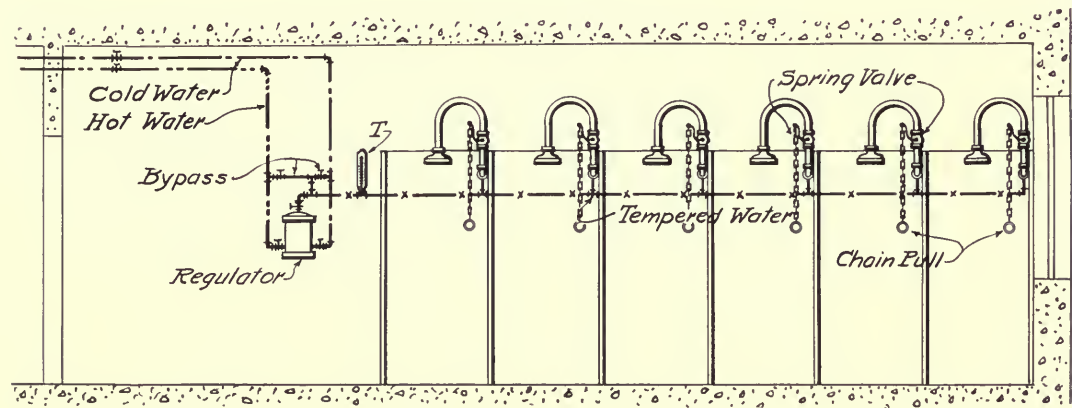


Fig. 102.

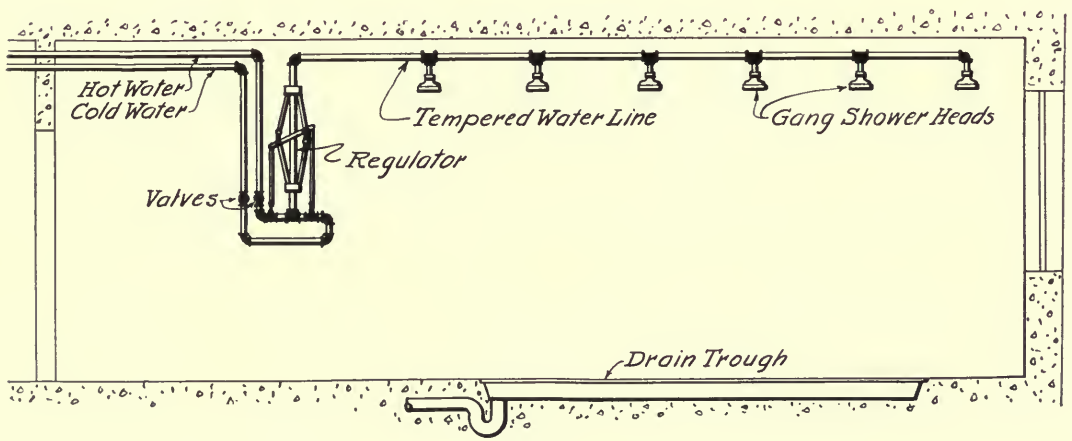


Fig. 103.

should always be made to prevent accidental scalding. This is necessary owing to the fact that hot water at a satisfactory temperature for other uses is entirely too hot to be used in a shower. In fact, the customary temperature for satisfactory service on sinks, lavatories and similar fixtures is generally assumed to be 150° Fahr., while many persons in a shower bath (especially young children) cannot endure water at more than 100 degrees.

It is, therefore, customary to install some means whereby water supplied to showers will not be hotter than 100° Fahr. in temperature

no hot water being supplied directly to the showers. The cold water line in addition to its connection to the regulator, is extended to and connected with the cold water side of the showers. Both of these pipes are usually concealed back of the slab work.

In each shower stall is placed a common shower mixing valve which—if of the anti-scalding type—opens the cold water first and then gradually closes the cold water and opens the tempered water line until pure tempered water is being delivered to the shower. Turning this handle back across the dial reverses the

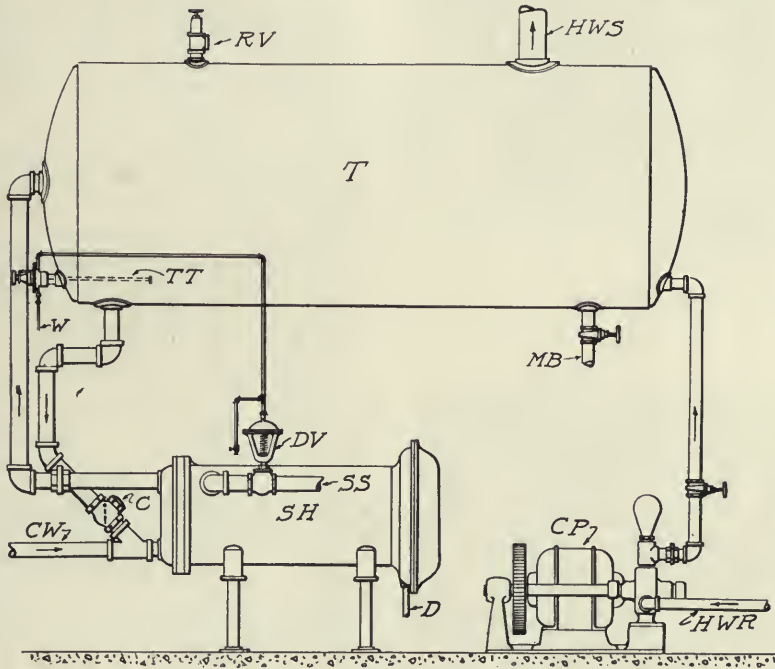


Fig. 104.

and also means whereby this temperature can be reduced to plain cold water at will. The exact method of this application depends considerably upon the character of the shower installations and the desired method of operation. Where individual showers controlled entirely by the pupils are used, the most common as well as the safest way, is shown in Fig. 101. Here a thermostatic hot water regulator supplied with both hot and cold water delivers tempered water (at 100° Fahr., or thereabouts) into a tempered water line. This tempered water line is connected to the hot water side of all the showers,

operation gradually shutting off the tempered water and turning on the cold water, until a cold water temperature is reached, then shutting off the cold water and thus stopping the flow of the shower. Showers arranged in this manner allow the individual pupil to control absolutely the temperature of water which he is using up to 100° (or other temperature for which the regulator is set) and down as low as the temperature of the cold water will permit. This scheme automatically keeps the showers shut off in stalls that are not in use, thus preventing the waste of water.

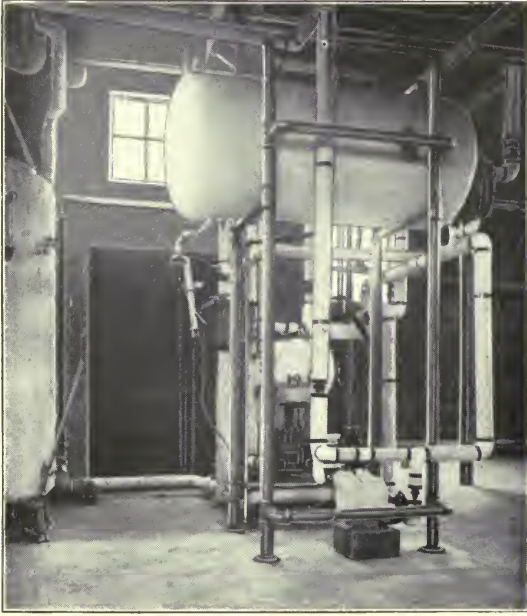


Fig. 98.

In cases where young pupils use the showers it is often desirable to have the instructor,

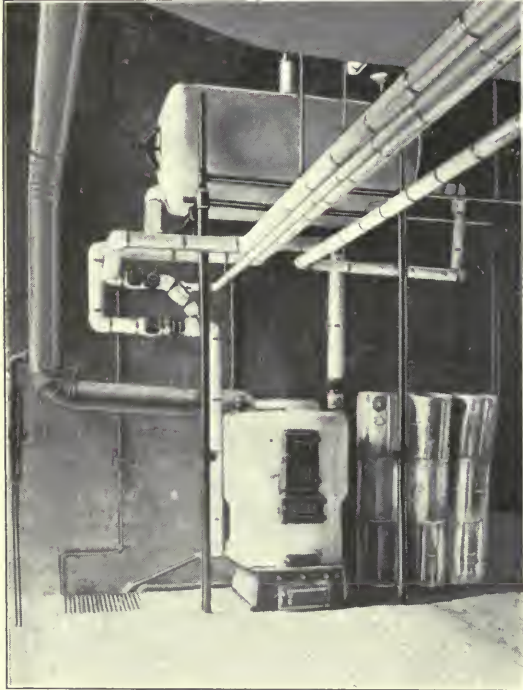


Fig. 99.

rather than the pupil, control the water temperature. To make such a control possible an arrangement as shown in Fig. 102 is sometimes used. In this scheme the hot and cold water is carried to a regulator like the one described above. No mixing valves are placed on the showers and no cold water connections are made to the showers; the shower heads are supplied solely from the tempered water line. In this arrangement the instructor standing at the regulator, can, by watching the thermometer T,

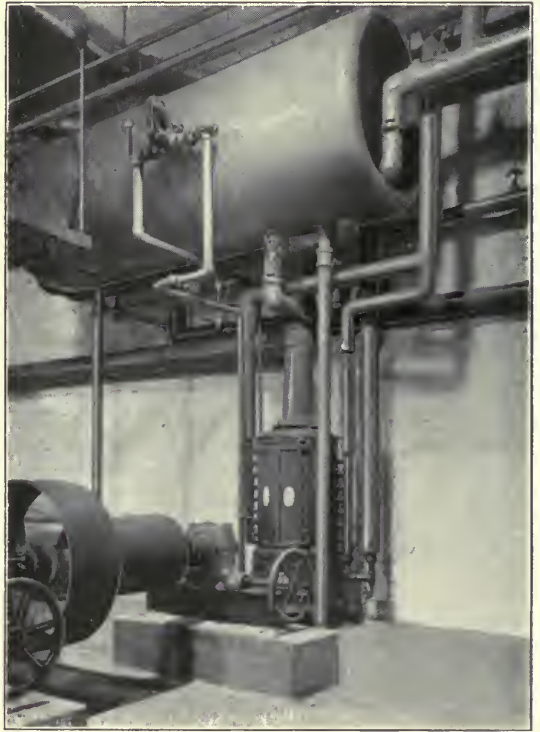


Fig. 100.

deliver water into the showers at any temperature from 100° down to the temperature of the cold water supply. The regulator will prevent scalding by not supplying water above the proper temperature. In case the regulator fails to operate properly at any time, manipulation of the valves on the bypass and close attention to the temperature registered on the thermometer T will allow temporary service until repairs can be made. The chain pulls shown in the showers are connected to spring valves which automatically close whenever the chains are

released. These are installed to prevent water waste.

In Fig. 103 is shown the common type of gang shower in which heads are located on the ceiling and the whole group is operated as a unit. In cases of this kind the number of heads is usually made sufficient to take care of an entire class or subdivision of a class so that the chances of not having a pupil under every head are small. Of course chain pulls and spring valves can be installed on the heads, but it is usually a problem to make the chains long enough to be reached by the smallest without making them so long as to strike the heads of the tallest pupils.

The hot and cold water comes in as before and goes to a regulator of different type from those previously shown. All water is delivered to the tempered water line by the regulator at any temperature desired. The water flow is controlled by the instructor who stands at the regulator and turns on the valve. As this regulator is practically fixed after being once set for a given temperature, a cold water bypass as previously illustrated is necessary to reduce the temperature below 100° when desired.

In some buildings it is impossible to get hot water circulation by gravity. This happens when two separate sections are so built that the only connection is a tunnel or other passage below the level of the hot water tank. This is quite likely to happen where a central plant is used to heat and light a group of school buildings.

Where such a contingency arises, circulation must be forced by means of a pump arranged somewhat as shown in Fig. 104. Here hot water is supplied to a building from the storage tank T thru the hot water supply pipe, HWS, returning from the building thru the hot water return line, HWR, to the circulation pump, CP, which forces the water to circulate. The tank is provided with a relief valve, RV, a mud blowoff, MB, and a thermostat TT, with a waste W.

The water is heated by the steam heater, SH, having a steam supply, SS, and a drip, D. This steam supply is governed by the diaphragm valve DV, operated by the thermostat, and circulation between the heater and tank is maintained by gravity thru the check valve C. The cold water supply enters at CW.

CHAPTER XI

Fire Protection

Every time we pick up a newspaper and read of a school fire, with the occasional accompanying casualties, we instinctively shudder. Death by fire is indeed horrible, but the slaughter of the innocent seems doubly so. The number of school children today housed in buildings without proper fire protection is a very high percentage of the total; and a thoro fire drill systematically carried out is no assurance of safety in case of actual need. Roughly speaking, school buildings may be divided into four classes, those strictly fireproof thruout, those with fireproofed walls and stairways and with slow burning construction otherwise, those of slow burning construction thruout and the common frame school.

All buildings need fire protection, *even* those which are fireproof. You can take an iron oven, fill it with excelsior, touch a match to it and—well, the oven *is* fireproof, but what chance would a human being have in it? A fire is *not* so likely to start in a fireproof building, it is *less* likely to spread to other rooms, *but* the interior of any building, together with its furniture, desks, equipment and combustibles, *can* be and often *is* burned. This must be guarded against.

The most common method of school fire protection is the installation of a system of stand-pipes with hose outlets and hose at each floor level and with one or more Siamese outlets at the building wall for the connection of the fire engine upon its arrival. Like a great many other things in common practice, the school fire hose is rather contradictory. In the first place, many schools have among their occupants only two adult male employes—the janitor and the principal—and even this number is reduced in some cases. If a 2½-inch hose is installed (which is the customary size) there is little likelihood of either of these two men being present exactly at the very time and place to operate the hose when needed. Under ordinary pressure it is absolutely impossible for a woman to direct the stream from a hose of this size, in fact (under high pressure) it often requires two or more firemen who are experts and thoroly

familiar with the handling of hose to properly control and direct it.

On the other hand, if the small size hose is installed (usually 1½ inches in diameter) it is hardly large enough to be effective in case a fire of any magnitude develops, as this hose is only slightly larger than a common garden hose. Moreover, a 1½-inch thread will not fit the fire department's standard hose, so that, in case of fire on the second or third floor, the firemen must, at a great loss in time, run their hose up from the ground level to get any quantity of water at the point required.

Everyone who has made a study of the origin of fires and the damage resulting from the same has arrived at the conclusion that the time to fight a fire is in its incipient stages—not after a conflagration has developed. *Prevention* is a thousand times better than cure! Operated under the above disadvantages, how, then, can we be assured that the installation of fire hose will protect our building and the pupils?

This naturally leads to the question, If not fire hose—what? The answer to this is something which, up to the present time, has been a considerable innovation in a school—namely, the automatic sprinkler system.

A system of this sort is being commonly installed in every modern building, be it for department store, office or manufacturing purposes. But, strange to say, the sprinkler system has seldom been employed in schools. Apparently children are not considered so valuable as merchandise, for the only objection that can be urged against the sprinkler system is its cost. Yet in many purely commercial cases the interest on the initial investment has been more than offset by the saving in insurance premiums, making it (even under the worst possible conditions) not as expensive as it would at first seem.

Briefly the automatic sprinkler system is nothing but a series of cold water pipes under pressure with heads located in the proportion of one to about 100 sq. ft. of floor area. The heads are plugged with a fusible metal which melts as

soon as the temperature rises to an abnormal degree. This temperature varies in different types of heads from 300 to 600 degrees Fahrenheit. To obtain the rough cost of installing a system in a school building the total area in square feet of all the floors should be added together and divided by 100 to give the approximate number of outlets required. The system will cost somewhere between six and ten dollars a head, the average being about eight dollars. A view of a sprinkler system for a typical classroom CR and wardrobe W is shown in Fig. 105,

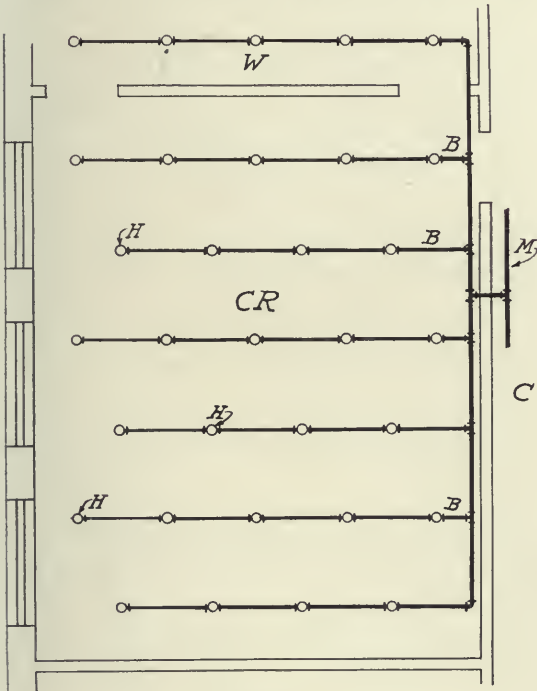


Fig. 105.

where a main M in the corridor C supplies the sprinkler heads H thru the branches B.

A sprinkler system properly installed constitutes a perpetual safeguard against fires, day or night, watchman or no watchman. In case a fire starts, all that is necessary is to wait for the nearest head to open up. Within five minutes after the opening of the head, either the fire is out or it has burned enough to open an increased number of heads by a continuation of the heat. This will result in such an increase in the amount of water as to make the further progress of the fire impossible. Valves located so as to control each floor, or portion of a floor, are then shut off and the flow is stopped. The

insertion of a new head and the re-opening of the valves brings the protection again into service with its original efficiency.

For school boards who feel that a sprinkler system is entirely too much of an innovation to thrust upon their local communities, I would recommend the use of the standard standpipe system with the pipes arranged so that the farthest portion of the building is not more than 75 ft. distant from the nearest hose outlet. Allowing 50 ft. of hose and 25 ft. length of stream, this will bring the extreme parts of the

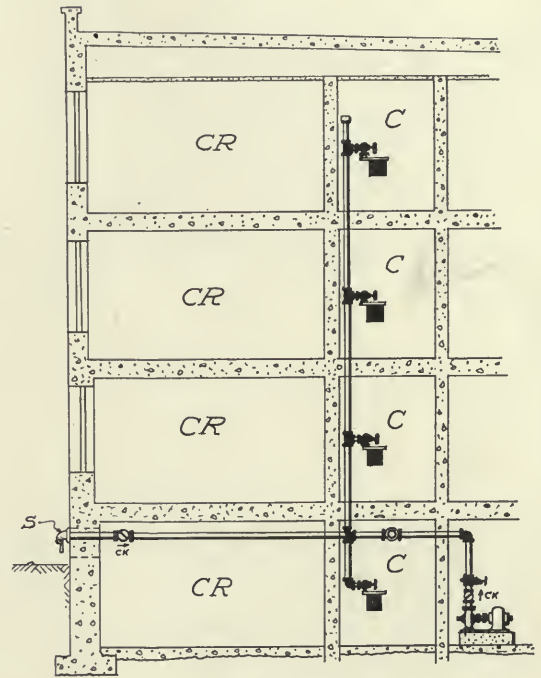


Fig. 106.

building within reach. The standpipes will probably figure out about 100 ft. apart, owing to the distance lost in going around corners. In an auditorium it is customary to place a standpipe somewhere near the rear so that a hose can be run in thru the entrance and serve the back part of the auditorium while another standpipe near the front, or in the rooms back of the stage, takes care of the stage and front portion.

The Siamese outlets are generally made two in number, so as to make connection to these outlets possible even should one be made inaccessible by a fire located in the basement close to the outlet.

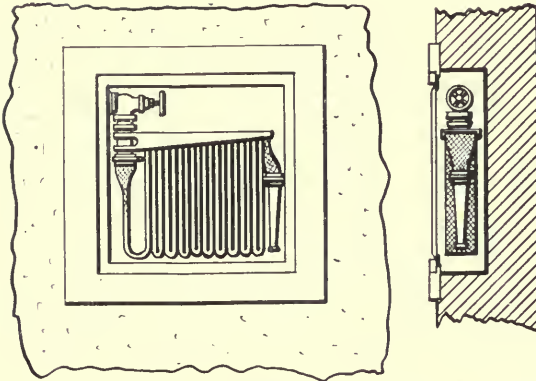


Fig. 107.

Fig. 106 shows a typical standpipe installation with the fire hose located in the corridors C just outside of the classrooms CR. This system is fed by the fire pump shown or by a city water connection until the arrival of the regular fire apparatus. The fire engines may couple their hose to the Siamese connection S and feed into the standpipe system thru the check valve CK, which allows water to pass inward but not outward. The standpipes, as many in number as required, are connected to the water main in the basement corridor.

It is customary in some schools to put the hose valve and hose rack in a recessed wall case

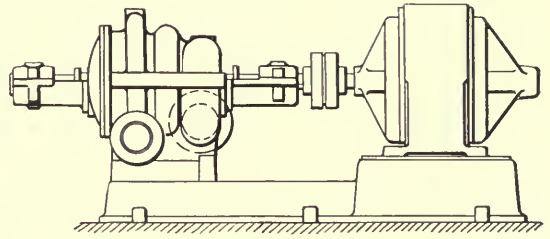


Fig. 108.

with a bronze frame and plate glass cover as shown in Fig. 107. This, however, is not to be considered as good practice as the plain exposure of the hose and valve, preferably in a corridor near the top of the main stairways. By the latter plan, everyone who is a regular occupant of the building must become aware of the position of the hose without any particular instruction. While it might be supposed that hose exposed in this manner would be subject to tampering by the pupils, strange to say this does not seem to be the case.

The fact should not be lost sight of that the standpipe from its very character is intended for the use of the fire department. This is indicated, first, by the Siamese connection intended for coupling on fire engines to supply water; second, by the common use of 2½-inch hose with thread to match the fire department's

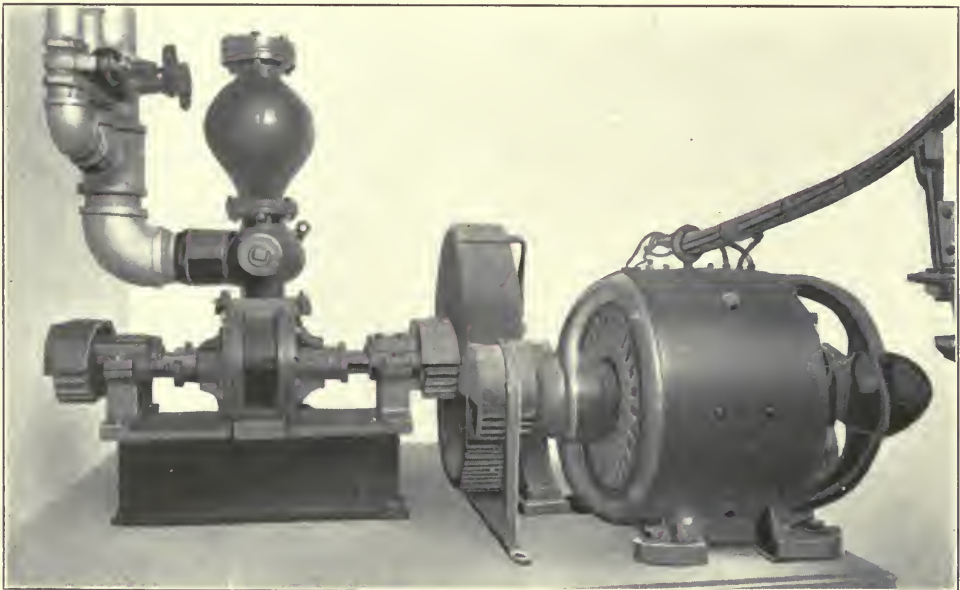


Fig. 109.

standard; third, by the usual lack of anyone in the building capable of controlling and operating such a hose in case of need, and last, by the fact that at the beginning of a fire a hose is *not* required, oftentimes doing more damage than good.

In either a sprinkler or a standpipe system it is desirable to provide some source of supply in addition to the general water system. The more sources, the less the chance of failure. A gravity tank (that is to say a roof tank or a tank on an elevated tower from which the water will flow by gravity into the fire system) is regarded as one of the surest sources of supply, because it does not depend upon any mechanical device to produce the flow of water, and the failure of power does not affect it. Still a supply of this sort is not by any means infallible. The tank may freeze; the valve in the supply from the tank may be closed accidentally; something may get into the tank and stop the outlet; or the tank may become dry thru accident or oversight.

When a gravity tank is available it is generally considered sufficient to cross-connect the standpipe supply to the water supply for the building, assuming that the pressure on the water supply is sufficient to operate the hose. If a gravity tank is not available it is customary to furnish two other sources of supply. One of the most satisfactory is the pneumatic system similar to that described for a pneumatic



Fig. 111.

water supply with a tank large enough to discharge about 3,000 gallons of water before failure. A second good source is a pump driven by an electric motor, steam or gas engine, which will keep up a continuous supply after the exhaustion of the tank.

It is well to provide this pump with a suction reservoir so that, in case the water supply to the building fails, the fight against the fire can still be carried on with the aid of the fire pump and the standpipe. A steam driven fire pump will not be satisfactory in a school where high pressure steam is not available at all times both day and night. A gas engine cannot be regarded as equal to an electric motor in reliability. On the other hand, an electric motor is usually dependent on current from an outside wiring system which can never be guaranteed to supply current without danger of failure at a crucial time. It is only by a combination of two or more sources of supply that the chance of not having water when the time of need comes is made so small that it can be safely neglected.

In general, fire pumps are electrically driven, especially in the newer installations. An approved Underwriters' pump of the motor-driven centrifugal type is shown in Fig. 108, and a rotary pump used for a similar purpose is shown in Fig. 109. It will be noted that both of these are direct connected, i.e., the shaft of the motor is coupled directly to the shaft of the pump without the use of gears, belts or other intervening devices.

For the use of the occupants of the building in the early stages of a fire, fire extinguishers are by all means the most satisfactory. These may be the regular chemical extinguishers, shown in elevation and cross-section in Fig. 110; or they may be small hand extinguishers. Either could be used effectively by a woman or even by a twelve year old child. These extinguishers are usually installed on a basis of one to every 1,000 sq. ft. of floor area, which means practically one to a classroom. This is on the basis of the Underwriters' requirements, but it would seem entirely practicable considering the division of schools into classrooms to place one

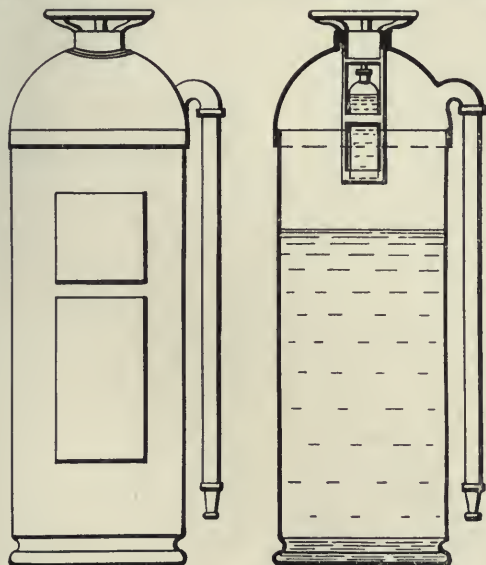


Fig. 110.

extinguisher in the corridor between every two classrooms.

The commonly termed "chemical extinguisher," shown in Fig. 110, consists of a copper shell partially filled with a mixture of bicarbonate of soda and water. The top is formed by a screw plug, which is turned by the wheel to which it is attached. On the bottom of the plug is a basket in which is set a glass bottle of sulphuric acid. Tipping the extinguisher causes the acid to flow slowly out thru the neck of the bottle and to mix with the soda and water, forming a gas. The resulting pressure drives the contents of the extinguisher out thru the flexible rubber tube on the side of the apparatus.

To operate the extinguisher it must be inverted and held in this position while the stream from the tube is directed on the fire. These extinguishers cost about seven dollars apiece and are, perhaps, the most common form of hand extinguishers.

Another very good type of chemical extinguisher is shown in Fig. 111. This extinguisher

is only 3 inches in diameter and about 14 inches long and the total weight is only 6 pounds. It is primarily a hand pump filled with a special chemical which is of a peculiar nature. Somewhat like quicksilver, it can be squirted onto the fire by manipulation of the pump handle, but it *does not* wet, stain or injure anything it strikes. It is without doubt the least damaging of all chemical extinguishers.

Modern development has placed one danger in the way of extinguishing fires—the electric current. Any hose or other means used to direct a stream of water in an electric fire is liable to have the current follow up the stream and shock the operator. This danger is present with all means of putting out fire excepting chemical in powder form, sand in pails, or the special extinguisher shown in Fig. 111. The chemical used there is a non-conductor and vaporizes into a gas as soon as it strikes a fire. These smaller extinguishers, while costing about the same as the larger ones, have a more extended use, not only for electric fires but for gasoline, oil, etc.

CHAPTER XII

Drinking Water

One of the peculiarities of unequal development in modern school sanitation is the progress made in some directions and the lack of progress painfully apparent in others. It would seem to one that cool drinking water which has been properly filtered and sterilized would indeed be one of the first requisites of a truly modern school. Still building after building is constructed without carrying the matter beyond the point of providing some very nice drinking fountains of the latest design, carefully connected up to the same cold water used to supply the lavatories and to flush the water closets. Doubtless some of this seeming inconsistency is due to the fact that schools are in general use during the cooler months only. Still the sessions often extend past the first of July and open early in September.

In most communities drinking water from a street main or driven well will be cool to a certain extent. In homes and other small buildings, it will be satisfactory. In larger buildings, however, where the supply must be carried in pipes a distance, thru the basement and up risers to the second and third stories, the water becomes thoroly warmed in transit. It has practically the temperature of the building and when it reaches the fountain outlets, has a disagreeably insipid, flat taste.

The newer office buildings, department stores and all new post office buildings of any size recognize the necessity of cooled drinking water

and are providing it. This provision assumes a simple character in the post office buildings (where greater economies in equipment are practiced than the average taxpayer is aware of) and grows more complex as the number of outlets, ice boxes and ice making requirements multiply.

The simplest form of water cooling consists of the common water cooler tank in which ice is melted in the tank to produce the desired lower temperature. This is not suitable for school use because the purity of the water becomes dependent on the purity of the ice. It makes necessary the objectionable practice of hauling ice constantly thru the building to supply each and every tank.

As an improvement over this there is the tank which forms merely a receptacle for cracked ice and its melted water, together with a pipe coil thru which the drinking water passes on its way to the faucet. The receiving end of this coil is connected to the cold water supply line and the discharge end is brought thru the side of the tank and connected to the faucet. As the water passing thru the pipe coil is never in direct contact with the ice, and is cooled only by the transfer of heat from the drinking water to the water from the melted ice during its passage thru the coil, the temperature of the water received is liable to be much more modified than

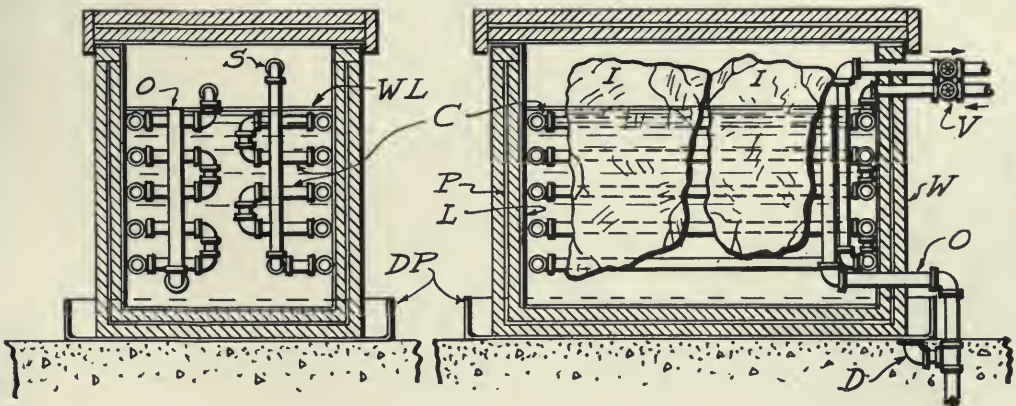


Fig. 112.

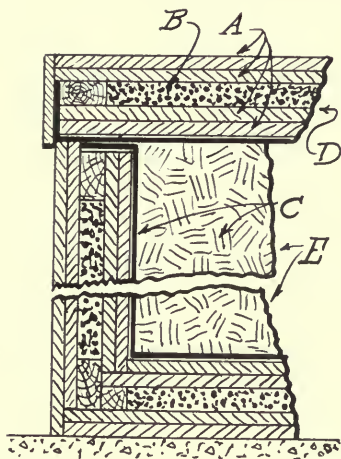


Fig. 113.

in the case where ice is melted directly in the water.

In such a tank, dirty or impure ice may be used with impunity as there is no connection between the water in the coil and the water from the ice in the tank. The modified temperature is, of course, an advantage as water has been found to be most desirable for drinking purposes when about 50° F. This scheme, however, is not desirable for schools as there is still the necessity of carting ice thru the building, while the coil is so small that it does not contain any reserve supply of cold water for a rush demand such as is likely to occur at a recess or lunch period.

If, however, all the drinking fountains are placed in the same relative position on each floor a small water pipe carried directly down to the basement from each group of fountains can be connected to a large coil of sufficient storage capacity for overload periods to properly meet the requirements.

A tank suitable for this type of installation is shown in Fig. 112 where the ice I floats in the melted ice water which is kept at a constant water line WL by the overflow O. The water to be cooled enters the coil C thru the upper pipe S and leaves thru the lower one as indicated by the arrows. The coil is contained in a tank built of two layers of $\frac{3}{4}$ in. wood W, with paper P between, and has an interior lining L of galvanized iron or copper. It is set in a drip pan DP, which has a drain D, and the water to and from the tank is controlled by the two valves V. Of course the size of the pipe and the number

of loops installed determine the storage capacity of cold water. After leaving this tank the water pipe is run directly up to the drinking water fountains.

This is also the scheme used in the United States Post Office Buildings except that the box in government buildings is slightly more elaborate in construction. The government boxes are built as shown in the detail, Fig. 113, in which A is $\frac{3}{4}$ by 2 in. beaded and matched lumber and B is finely packed granulated cork. C is a No. 26 gauge galvanized iron lining which covers both the interior of the tank E and the bottom of the cover D, with soldered joints. The cover is hung with iron hinges and is provided with a lifting handle. The box is set on a yellow pine frame which lifts it 6 in. above the floor. It contains about 50 ft. of $\frac{3}{4}$ in. block tin pipe which is made continuous and without fittings inside the tank.

To operate all drinking water from a central point some form of refrigeration and water circulation is required. For small installations in which simplicity and fool proof mechanism are desired, there is a patented machine known as the Audiffren-Singrun, which uses sulphur dioxide as its refrigeration agent. This consists of a shaft upon which are mounted two sealed chambers in which the refrigeration agent is compressed and expanded. By operating the expansion chamber in the water to be cooled the desired refrigerating effect is obtained, and there is no possibility of leakage of ammonia fumes or other troubles from which larger plants sometimes suffer. The machine is sealed in the factory and is operated by an electric motor and a supply of cooling water. It should be understood that the heat absorbed by the cooling water is approximately the amount of cooling effect obtained in the drinking water and that the whole process of refrigeration consists simply of the transfer of the heat from the drinking water to the cooling water (which often gets quite hot) thru the medium of the refrigeration agent used. All power which is consumed is consumed by this process of heat transfer.

Probably three-quarters of the refrigeration systems installed are of the ammonia type, that is to say, ammonia is used as the refrigerating medium. This is the case in the West Philadelphia High School in which a modern refrigeration plant is installed. In this school drinking fountains are placed in the corridors, in the

basement, near the pupils' lunchrooms, in the vicinity of the shower bathroom and in the corridors of all floors of both wings. The cooling plant is placed in the basement and consists of an ammonia compressor driven by a 25 H. P. motor, a cooling tank 3 ft. by 6 ft. by 12 ft. long, an ammonia condenser, an ammonia receiver, an oil separator, and a pump to circulate the water to the fountains and back again. A plan of this equipment is shown in Fig. 114, which is self-explanatory.

The cooling tank is of $\frac{1}{4}$ in. steel set on a concrete foundation with two layers of 2 in. cork beneath. The tank itself is insulated on the sides by cork about 10 in. thick, sheathed with two thicknesses of 1 in. pine and four-ply tar paper. The coil in the tank in this case contains ammonia, the expansion of which produces an intense cold, thus cooling the water in the tank. The coil is of 2 in. extra heavy ammonia pipe and has a capacity of cooling 1,600 gallons of water from 70 degrees to 40 degrees in five hours.

The process in this plant consists of compressing the ammonia gas to a high pressure in the ammonia compressor, the compressor discharging into the pipe marked "Ammonia Discharge" on the plan. The ammonia gas which is at a high temperature owing to its compression, is then passed thru the oil interceptor from which it is carried down to the condenser. The condenser consists of double pipes, the inside pipes being $1\frac{1}{4}$ in. and the outside pipe 2 in. in diameter. One pipe contains the ammonia and the other pipe cold water obtained from the city mains. The cooling of the gas passing thru this condenser results in its liquefaction. After liquefying, the gas is collected in the receiver. The liquid gas is now of ordinary temperature but at a very high pressure. From the receiver it passes thru the line marked "Ammonia to Tank Coils" to the "Expansion Valve." This valve allows the liquid to pass from the high pressure of the receiver into the low pressure of the cooling coil. This results in the ammonia vaporizing and absorbing a large amount

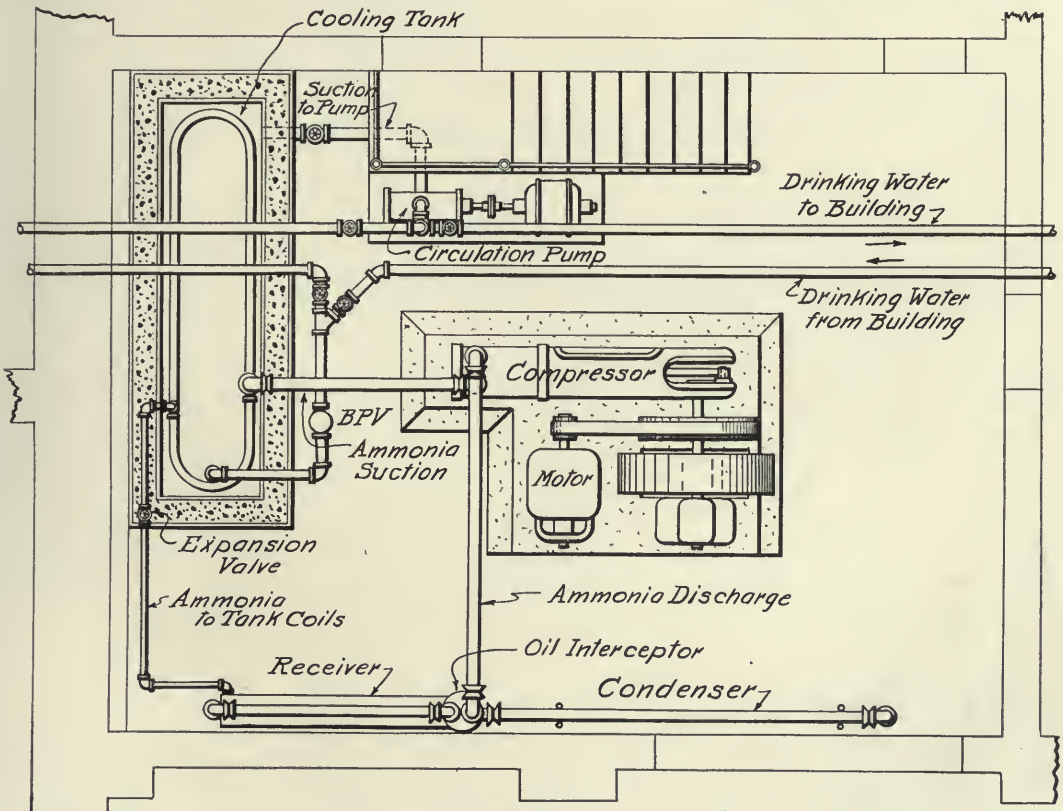


Fig. 114.

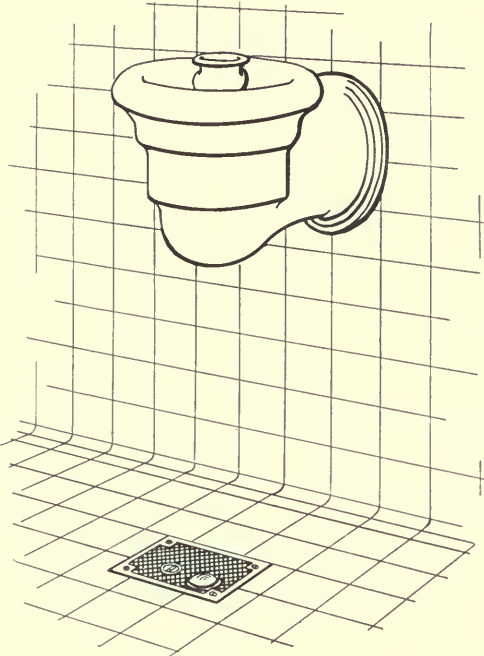


Fig. 116.

of heat, this heat being taken from the water in the cooling tank. The gas in the coil is then

drawn thru the ammonia suction pipe back into the compressor and recompressed ready for a second round of the cycle.

This is the ammonia system from which the drinking water circulation is entirely separate, the only connection between the two being in the cooling tank where the expansion coil is immersed in the drinking water. The warm water coming back from the building is carried thru a back pressure valve BPV, which prevents the water from running out of the system into the cooling tank. After passing thru the back pressure valve it enters the cooling tank where the water level is maintained by an automatic device which supplies make-up water to replace that drawn off in the building. In the cooling tank the water is brought into contact with the cooling coil and chilled to the desired temperature. The coldest water falls to the bottom of the tank from which it is drawn off thru the suction pipe to the circulation pump and discharged into the line supplying the building.

The drinking water in a system of this kind and, in fact, in the previous system where sulphur dioxide is used, must be circulated by a circulation pump so as to flow as continuously

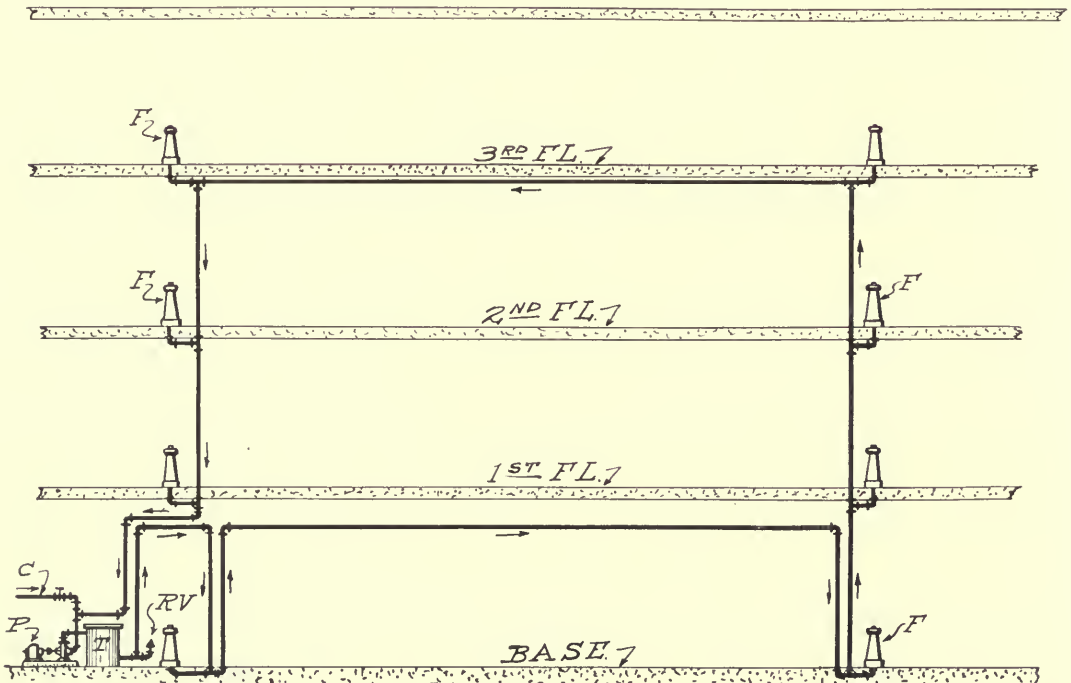


Fig. 115.

as possible to the various outlets. The outlets must be placed as near the circulating main as possible to avoid dead water in the pipe between the faucet or bubbler and the circulating main, and to avoid wastage in drawing this dead water off.

In Fig. 115 we have a typical system of this kind installed in a three story school supplying eight fountains F and circulating thru the piping in the directions indicated by the arrows. The return pipe coming back from the system is united with the cold water make-up C from which the water enters the pump P and is then discharged thru the cooling tank T and then thru the pipe circuit as shown. RV is a relief valve to allow for expansion in case the system should be stopped and the water allowed to warm up. In the warming process there would be a certain amount of expansion that would exert great pressure if not properly relieved.

The fountains shown in Fig. 115 are what is known as the pedestal type and may be located upon the floor at any convenient point. Another very popular type of fountain for school work is shown in Fig. 116. This fountain is operated by what is known as the pedal control consisting of a valve in the floor box which is operated by stepping on a ball projecting about $\frac{1}{2}$ inch above the box. It is obvious that this type of fountain can be used only on a vertical

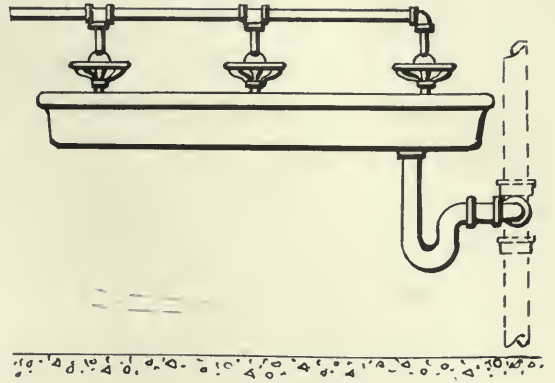


Fig. 117.

wall. Both the pedestal and the wall type may be operated from the floor or by means of a spring valve handle in the side. In cases where one fountain is not sufficient to avoid undue expense the receptor type is generally used. A typical fountain of this type is shown in Fig. 117. It consists simply of a supply pipe running to bubblers which are opened by pressing down the hand wheel around the bubbler. The water from these outlets is caught in the receptor which has a trap to the wall and resembles a common sink in every respect except the faucets.

CHAPTER XIII

Sewage Disposal

The subject of sewage disposal for schools located in unsewered districts is one which often causes considerable anxiety to school boards. Generally the trouble is accompanied by a larger or smaller amount of expense which may, or may not, be necessary. A great deal of the trouble and considerable expense can be spared by selecting a location where the slope of the site and character of soil are suitable for a small disposal plant. In fact, it can be proven that in certain cases the ground may be so unsuited for sewage disposal as to make the purchase of a more expensive site (which is better suited to the end desired) an economical procedure in the end.

In general, sewage disposal for a school should not include the water from the roof as this produces an excessive amount of liquid to take care of in a very short time and at infrequent periods, so that the plant must be designed entirely too large for at least nine-tenths of the time. This in itself will operate so strongly against the requirements of the septic tank (explained later) as to make success almost impossible. It will in addition require a much larger initial expenditure for needless capacity. The roof water should be carried to nearby dry wells, spilled into a creek or gutter, or (if desired) it can be collected in a cistern and pumped into a tank from which it may be drawn to flush water closets. Assuming, therefore, that the roof drainage may be neglected in this particular discussion, the disposal system must take care of all drainage for the building which will average about 100 gallons per day per person in ordinary structures occupied 24 hours per day. A school, however, is not occupied for this length of time; no laundry work is done there and little water is used for culinary purposes. In consideration of these facts the amount of sewage per pupil drops from 100 gallons to about one-third, to approximately 30 gallons per pupil per day.

There are several methods of sewage disposal which can be used; the intermittent sand filter system, the contact system, the percolating filter system and the field absorption system. It is

sufficient for the purposes of this discussion to say that most disposal systems (excepting that of field absorption) employ open tanks or filters and that such installations are not desirable for school work owing to the odors, to the danger of pupils falling in, etc. How a disposal system can take raw sewage and without the addition of any chemicals or other ingredients and without any mechanical manipulation whatsoever can produce a resultant, free from germs and comparatively harmless is indeed wonderful. That this discharge can be purified to a point exceeding that of drinking water is little short of marvelous! Such are the facts, however, and the results are obtained simply by the intelligent use of the natural laws and forces which we have at hand.

Sewage is composed almost entirely of water. This water carries a few other substances such as waste matter, soap suds, grease and other ingredients, and some insoluble minerals which may get into the system. It is a well known fact that animal and vegetable matter when thrown upon the ground will putrefy, or rot, and gradually disappear. In fact, the original sewage disposal system consisted of this natural process to dispose of the slops and filth. Where too many slops were thrown in the same spot the ground became water soaked and turned sour. This process, scientists tell us, is entirely due to the activity of bacteria. These bacteria divide into two classes, one of which breaks down or decomposes the material and the second of which purifies or makes harmless the resultant. Let us see how this can be applied to the modern septic tank.

The modern septic tank is generally built somewhat in the shape shown in Fig. 118, the sewage entering a chamber A thru the inlet I, passing under a partition E, into the septic chamber B. The sewage decomposes as it moves slowly thru the chamber towards the division wall F. When the sewage enters the tank the heavier portions and those which are insoluble settle to the bottom forming the sludge indicated by X. After the tank has been in service for some time a spongy, slimy mat is formed in

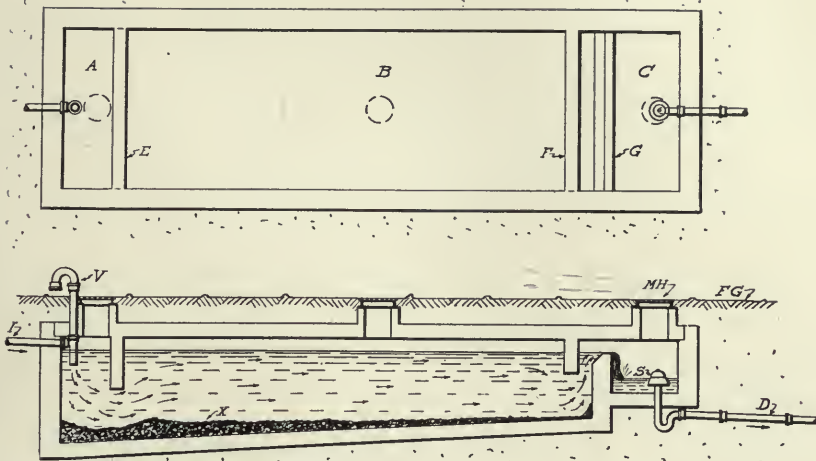


Fig. 118.

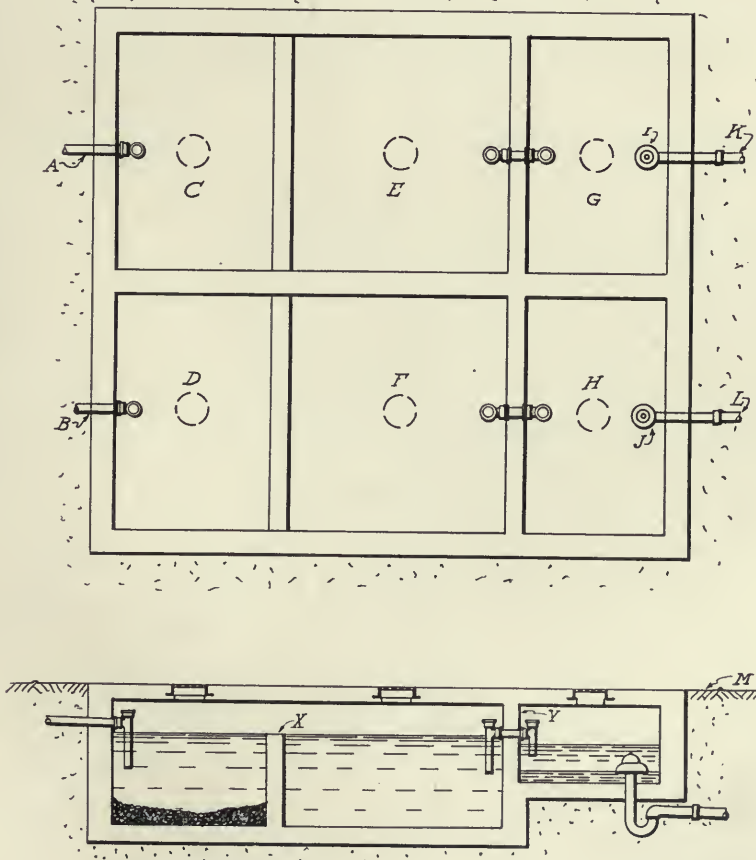


Fig. 119.

chamber B. This mat floats on the surface of the water and serves to colonize and multiply the bacteria in the tank. Access to the tank is obtained thru the manholes MH, which are set at the finished grade FG. After it is completed the tank is invisible, being entirely buried under-ground. Only the three manholes and the vent V extend up to the surface of the ground and are visible.

who think a septic tank is a sort of a sewage panacea. The remaining work consists of rendering this discharge pure and of absorbing it or of taking care of it in some other inoffensive manner.

Before we leave the subject of septic tanks let us glance at Fig 119 which is another type of tank to serve the same purpose. This tank is built with a center division and has two in-

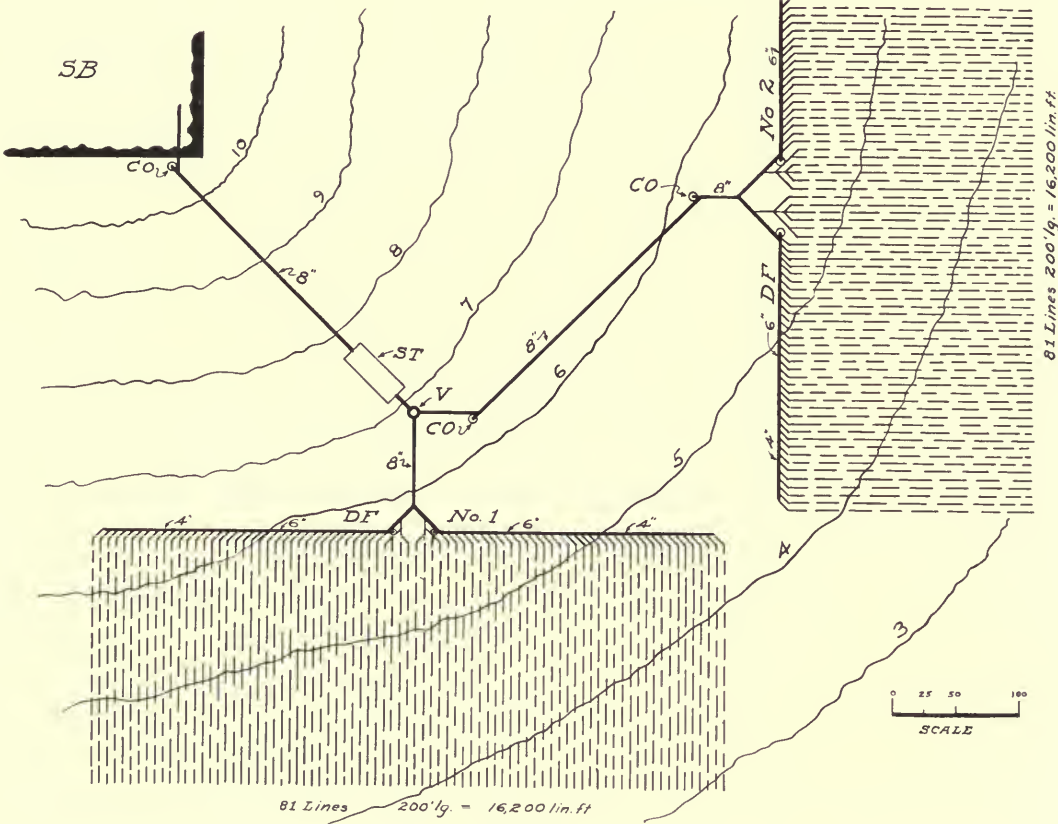


Fig. 120.

By the time the sewage reaches the dam G it has become a thoroly dissolved solution which pours over the dam into the chamber C known as the discharge or "dosing" chamber. In this chamber the outlet from the tank is located. This outlet is governed by the syphon S which discharges thru the drain D intermittently for purposes later explained. Now the action in the septic tank, it must be thoroly understood, is only half of the complete purifying operation. The discharge from the tank is not harmless or odorless, contrary to the ideas of many people

lets, A and B, and two outlets, K and L, governed by the syphons, I and J. The sewage entering at A passes into chamber C which is known as the "settling" chamber. All the heavy matter sinks to the bottom in this chamber and the water overflows the dam X into chamber E (known as the "septic" chamber) where the septic action takes place, altho some decomposing work goes on in chamber C as well. After passing thru chamber E, the middle stratum of the water passes up thru the pipe in the wall Y and thru the wall into the dosing chamber G.

Similar action is followed on the other side of the tank where the sewage coming in at B, passes thru D, F and H and then out of the dosing chamber by means of L. It will be noted in the sectional view that this tank is shown as set flush with the grade M so that the whole top of the tank is exposed. Either this or the method used for the first tank is permissible.

For the purposes of this article a tank for 500 pupils has been shown. This is because few elementary schools exceed this number of pupils, particularly in sections where no sewers exist. Therefore, it is the disposal equipment shown for the maximum condition likely to be encountered.

The most important points of septic tank design relate to the cultivation of the bacteria therein. It is a remarkable fact that a new

that the septic tank gives less and less satisfactory results as the sewage discharge into it becomes more and more intermittent and irregular.

The sewage in passing thru the tank becomes too far fermented if it remains more than 24 hours and on the other hand is not properly acted upon if it remains less than this period. This is one of the reasons why a septic tank applied to schools will not give as satisfactory service as one applied to an institution such as a hospital or alms house where the building is occupied both day and night and seven days a week. In fact, septic tanks have been found to be quite impracticable for churches where they are used only one day a week. Therefore, for 500 pupils at say 30 gallons each per day, the total daily sewage will be 15,000 gallons. This

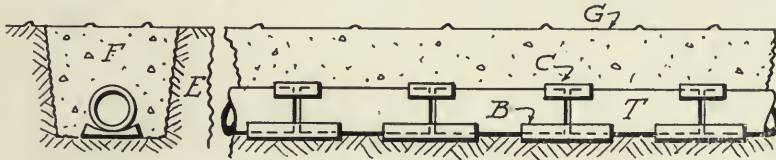


Fig. 121.

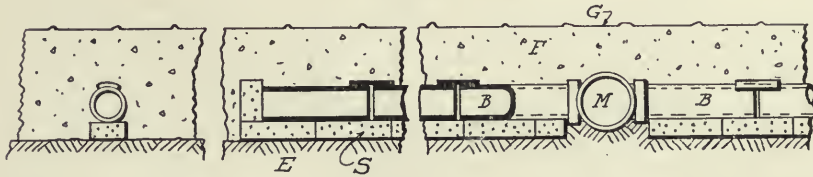


Fig. 122.

septic tank gives but little satisfaction for a period of approximately six weeks which is the time required to develop the bacteria to their most active condition. The condition of inactivity also follows whenever a tank is cleaned, unless a portion of the "mat" is retained and "planted" in the new tank to accelerate fermentation.

In passing thru, the water in the tank should be agitated as little as possible so as not to hinder the formation of the mat, maintaining the same intact after it has formed and also in order not to disturb the sludge or non-decomposing material which settles to the bottom. As the bacteriological action which goes on is a *constant* one continuing unceasingly in the darkness both night and day, it has been found that the best results are obtained where the discharge of sewage into the tank is constant or almost constant during the whole 24 hours and

reduced to cubic feet (15,000 divided by $7\frac{1}{2}$) gives 2,000 cu. ft. This is the required capacity of the tank exclusive of the dosing chamber. In the second tank shown the combined capacities of both sides must be considered.

The discharge from a septic tank for schools should be taken care of if possible by what is known as a disposal field or rather two disposal fields. Two fields are desirable since it is necessary to turn the sewage into one field one day and into the other field the next day, giving each field a breathing space of 24 hours in which to dry out. A typical case of this kind is illustrated in Fig. 120 in which the school building SB is supposed to house 500 pupils. The 8 in. sewer leaves the building and flows down to the septic tank SB (the detail of which has already been shown in Fig. A). After leaving the septic tank the sewage goes to the three-way valve V

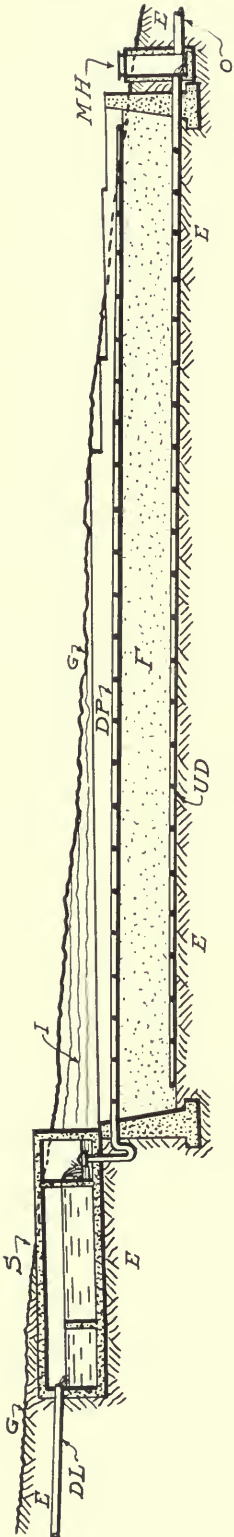


Fig. 123.

which throws it into one of the two branches leading to disposal field "DF No. 1" or to disposal field "DF No. 2."

It is essential in order to get a flow from the building to the tank and then to the field that the field be located at a lower level than the point at which the sewer leaves the school basement. If this is not the case pumping must be resorted to which is very undesirable as well as costly. The lines on Fig. 120 marked 10, 9, 8, 7, etc., are grade lines, each line indicating the fall of a foot in the ground level going from the building to the field.

The disposal fields themselves consist of 3 in. tile pipe T, as shown in Fig. 121. The bottom of these tiles is about 10 in. below the surface of the ground, G. They are laid with open joints covered by a cap C and set in a trough B, which allows a small amount of leakage at each joint. Where the earth E is not of a porous or absorbent nature these tiles are buried in trenches which are filled in with sand and gravel F so as to facilitate the absorption of the discharge from the septic tank. Another method of laying tile for these fields is shown in Fig. 122, where the finished grade is indicated by G, the original earth by E, a special absorbent filling by F, the main distribution line M supplying the branches B which are in-

stalled upon bricks S so as to keep them properly lined up.

To prevent these fields from becoming soggy and sour by constant applications they are used alternately, but even this is not sufficient. If the septic tank discharged a constant flow the ground in the field nearest the point of entrance of the pipe line would be over saturated by the constant supply during every other day and the remote portions of the field would never be reached. To overcome this objection the dosing chamber is installed in the tank into which the sewage passes until the chamber has been filled to a predetermined level. When this point is reached the syphon is filled and once the flow is started it continues until the chamber is emptied to its low level. This results in supplying enough liquid to penetrate all portions of the field before it can leak out thru the joints, thus, as it is technically termed, "dosing" the field thoroly.

After the discharge from the tank enters the soil it is set upon by the second class of bacteria which require air in order to properly do their work. These bacteria are thickest at the surface of the ground and gradually disappear until at the depth of five or six feet they are practically extinct. These bacteria soon render the tank discharge practically harmless so that it amounts to little more than introducing an equal amount of water in the soil. This water is rapidly absorbed and vaporized in the field so that no drains beyond this point are necessary.

Another method whereby more superior purification results can be obtained is known as the intermittent filter disposal system, an idea of which can be obtained from Fig. 123. Here the drainage line DL enters the septic tank S as before. After passing thru the tank the sewage is discharged by a syphon to the distributing pipe DP which is laid on top of a filter bed F. This bed is made of broken material allowing more or less free circulation of air down into the mass. After dripping thru this material which is confined in a concrete basin the liquid finds its way into the underdrain UD which discharges it into the manhole MH. From this an outlet is taken into a nearby stream or lake or into a similar secondary filter and even in some cases (where the highest degree of purification is desired) thru a third filter. In this figure, G indicates the finished grade, I a slope down to

the top of the filter bed, and E the original earth. Filter beds of this type must be open and while giving a greater capacity of absorption for the same ground area they are not as desirable for schools as the disposal field. Of course

it is desirable with schools to have everything covered from inquisitive pupils so far as possible, and for this reason the disposal field is the most desirable method of taking care of the septic tank discharge.



A SCHOOL LABORATORY.

CHAPTER XIV

The School Power Plant

Few school boards realize the economy of a school power plant and fewer still adopt the idea even after being convinced. The reasons for this will appear later, but regardless of the variety of objections often urged against such installations, their desirability is beyond question in many cases.

It must be understood at the start that a power plant consists of boilers, engines, generators, feed water heaters and the other apparatus necessary to produce electric current sufficient for the needs of the school. With such current available, it should be used for any and all purposes wherever necessary in order to secure the maximum advantages at minimum cost.

Electric current for motors, lights, experiments, etc., is daily becoming a greater and greater necessity in the modern school building. As an example of this it may be said that one of the new Pittsburgh High Schools uses for ventilation alone some 23 fans, several of which require motors from 30 to 50 horsepower each. Having once installed a power plant, current in any reasonable amount can be generated for school use at little or no additional expense.

This is explained in the following manner: Steam must be generated to heat the building in any event and to produce this required amount of steam a given amount of coal must be consumed. Now if this steam is raised to 60 lbs. or 100 lbs. pressure (instead of only the 5 pounds usually carried on low pressure heating systems) there is a tremendous amount of energy available which can be turned into electric power by passing the steam thru an engine connected to a generator with a loss of only a very small portion of the heating capacity of the steam. After passing thru the engine about 95 per cent of the original heating value of the steam is available in the exhaust steam, at 5 pounds pressure, for heating the building.

The steam required for *heating* is usually so far in excess of the amount required for *power* that little if any additional steam is ever needed for power purposes, except on warm days in the spring and fall when no heat is required. At these times the steam required for power must

be produced for this special purpose and, instead of being turned into the heating system is thrown out thru the free exhaust pipe. Were it not for this waste in warm weather, power could be produced even more profitably than at present.

Some one in making a comparison of the cost of buying current from a lighting company and producing current on the premises combined with using the exhaust steam for heating, has deduced the fact that even if the lighting company could produce its current free of charge the cost of distribution alone is sufficiently high as to make a private plant cheaper. This statement however, must be limited in its application to large consumers and to districts not immediately adjacent to large central power stations.

There need be no concern for the safety of a high pressure plant in a public building, such as a schoolhouse. There is no reason to rule against a plant in this particular. Almost all large office buildings, large department stores and the large majority of manufacturing establishments own and daily operate plants of exactly this description. High pressure can be, and is, made as safe as low pressure, while greater and more numerous safeguards are installed to prevent even the possibility of accident.

As to cost: The average school can make all the changes necessary to install a plant at a cost approximating \$10,000.00. The fixed interest charge on this amount will be about \$500 per year to which must be added depreciation, repairs, extra coal, attendance, etc. The amount of depreciation is usually considered as about 5 per cent per annum and the upkeep about 2 per cent which gives some 12 per cent (counting fixed interest charges) of the initial investment to be charged up to the cost of running the plant each year. There will also be some additional coal used to supply power only, during the warmer days of the late spring and early fall. Just how much this would amount to is problematical depending on the season, amount of power used, fireman, etc. It would probably be fair to assume about 90 to 100 tons

might be used costing perhaps some \$400 to \$500. Additional labor in the boiler and engine room might cost another \$400 and engine room supplies such as oil, waste, etc., about \$100.

From this it can be seen that a plant costing \$10,000 initially would require

10,000 x 12% equals	\$1,200	fixed charges
	500	additional coal
	400	additional labor
	100	miscellaneous

\$2,200 total operating
cost per year,

or a monthly average for ten months of about

\$225. Just at the present owing to the abnormally high prices, the initial cost of a plant might, and probably would, somewhat exceed the above estimate but this would affect the yearly operating cost but little especially when distributed over ten months during the year. The modern high school, however, has but little difficulty in running up an electric bill of \$600 to \$1,200 per month depending on the rate paid, amount of night school, and minimum rates for summer use when the school is not in session.

The economy of school power plants may perhaps be understood better thru a description of a typical power plant installed in 1915 in a

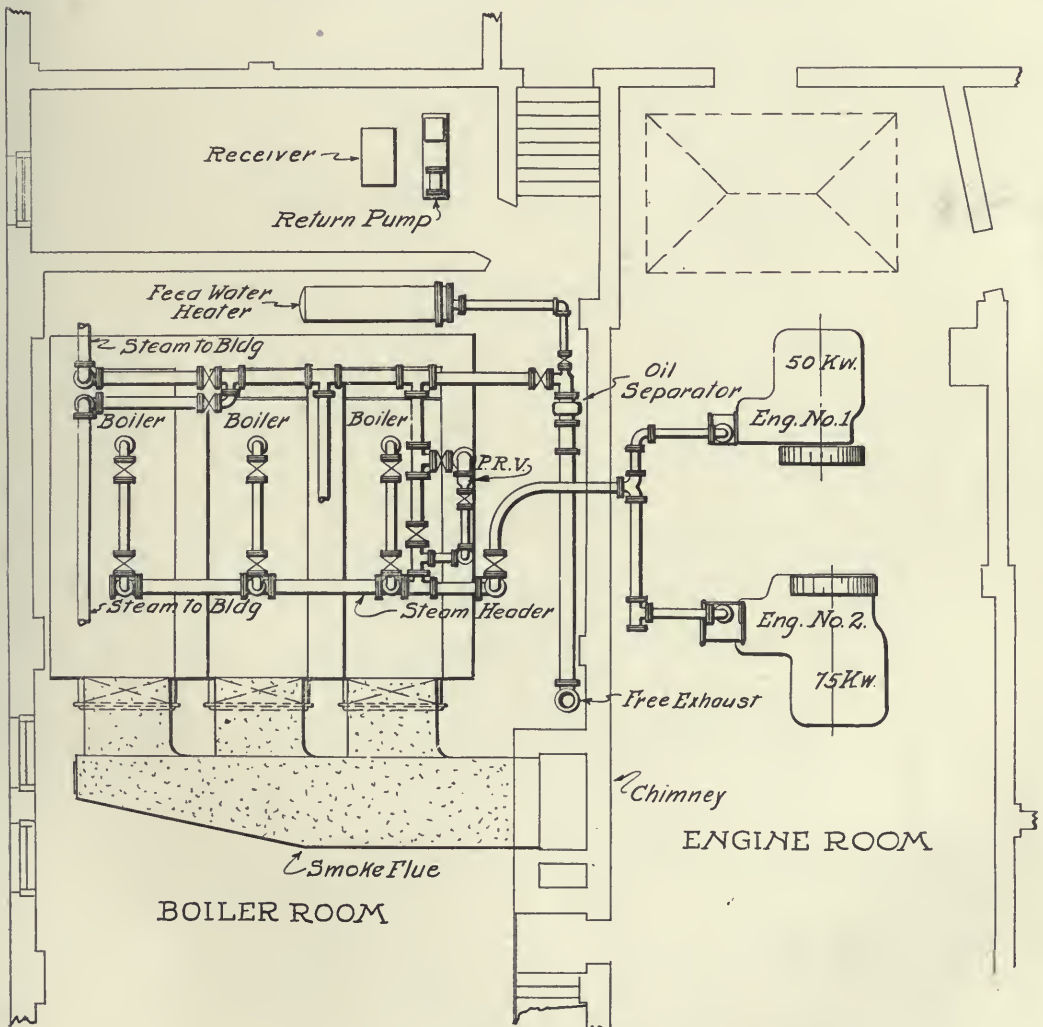


Fig. 124.

high school in an Eastern city. This plant has given the utmost satisfaction to the board in charge. The original intention was not to install a plant but on the contrary to construct a swimming pool. Tentative estimates on the cost of the pool and of its operation caused the board of education to abandon the proposed plans. The space was very conveniently turned into an engine room when the board realized that an annual saving of more than \$1,500 could be made by such an arrangement.

It is always well in installing low pressure heating plants to provide (as was done in this case) boilers designed to stand high pressure so that power can be generated in them later if desired. The additional cost of such boilers is not much, and their usefulness for possible future power purposes is desirable. For this reason cast iron boilers are not well suited for large schools where power may be desired later. Cast iron boilers cannot safely carry high steam pressure under any condition.

In the particular case referred to, two generating units were installed, one of 50 kilowatt and the other of 75 kilowatt capacity. One of these units can be run in case the other breaks down, but the larger unit must be utilized when the auditorium is used at the same time as the classrooms. This condition is, of course, very rare.

The three boilers shown in the plan in Fig. 124, supply steam to a high pressure header running across the boilers near the front. From this header all steam is taken; the branch at the right hand end goes thru the wall into the engine room and supplies the two engines. Just to the left and in front of the boiler connection

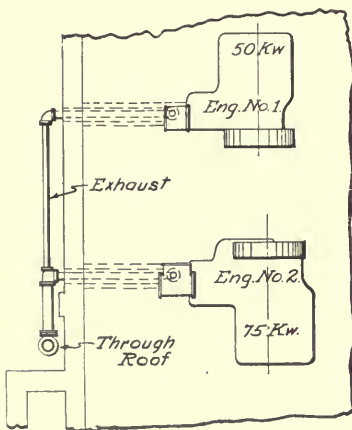


Fig. 125.

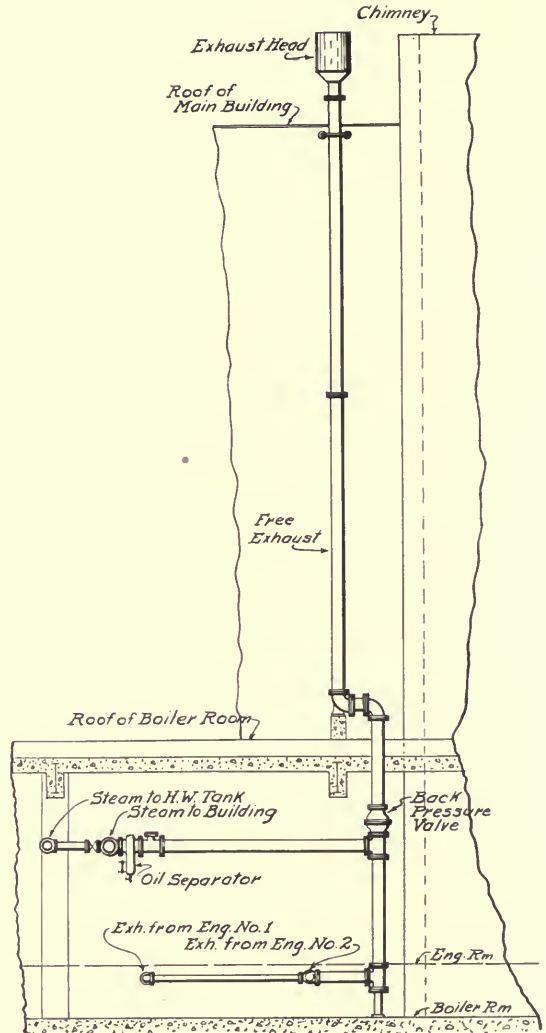


Fig. 126.

is a steam connection, passing thru a pressure reducing valve PRV and into the header extending across the back of the boilers. From this all steam for heating the building is taken. A branch from this header also supplies steam to the feed water heater.

To understand the free exhaust and oil separator, the plan shown in Fig. 125 must be referred to and the path of the exhaust must be followed. This exhaust pipe is laid in a trench underneath the floor to a vertical riser, marked "Thru the Roof." The exhaust steam is carried from the engines into the exhaust to the vertical riser. At the ceiling this riser has a branch

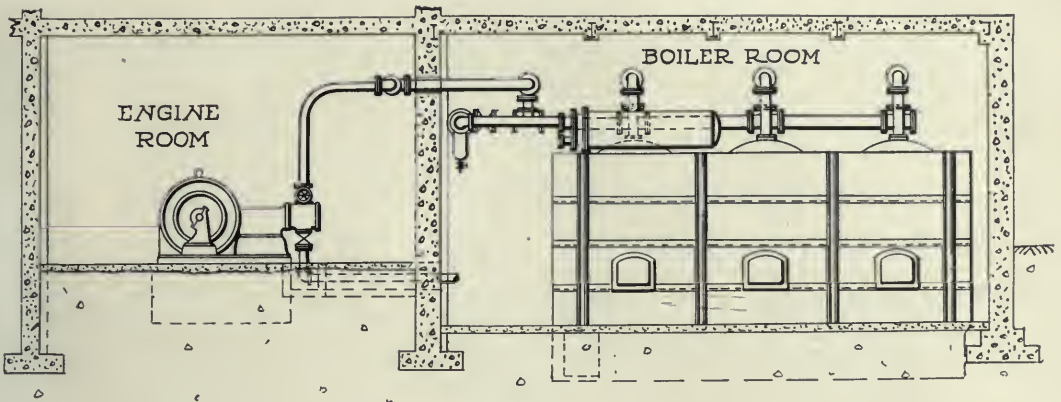


Fig. 127.

going thru an oil separator into the heating system. In warm weather the exhaust steam enters a second branch thru a back pressure valve directly to the outside air. The method of pipe arrangement is shown in Fig. 126, which is an elevation of the riser with the branch to the oil separator and the extension of the riser to the exhaust head on the roof.

A cross section thru the boilers and engine room is shown in Fig. 127. This view also indicates how the exhaust pipe is carried under the engine room floor.

After completion, this plant was carefully tested out and has since given every satisfaction.

In this school the boilers were installed before the final decision was made by the board to install a plant. Owing to the foresight of the engineers these boilers were, luckily, capable of carrying high pressure so that the changes were limited to the installation of engines, piping, feed water heater, etc. The plant is saving yearly more than \$1,500 (in some years nearly \$2,000) per year which is equal to a 20 per cent interest rate on the investment of \$10,000. Of course some extra coal, attendance, oil, etc., are required but these are not sufficient to seriously impair the good showing made.

Objection to a school plant is sometimes urged on the basis of dirt and noise. Both of these charges are unfair to properly designed plants. Many engines are so well built and carefully balanced that a person standing just outside of the engine room door cannot tell whether they are in operation or not. So far as dirt is concerned, the engine room is far cleaner than any boiler room. This may be readily seen from the two views accompanying this article. Fig.

128 is a view of the boiler room and Fig. 129, a view of the engine room. The pictures show that the latter is absolutely clean beyond any possible censure.

Sometimes such seeming difficulties are encountered as a requirement for a small amount of power for the operation of a small motor or a few lights. In the building described it was desired to run the house pump—which supplied water to the tank on the roof—during the summer and also to furnish light to the offices occupied by the school board and administrative officers. For this purpose a gas engine of $9\frac{1}{2}$ horsepower, operating a $7\frac{1}{2}$ kilowatt generator, is used as an emergency. It is run only for small power requirements when the main plant is not in operation. A view of this equipment including the house pump is shown in Fig. 130.

There are several reasons why schools which are large power consumers should be built so as to make the installation of a plant possible:

First—A school, capable of economically installing its own plant so as to compete with the local service company, can generally secure a reduction in the rate charged for current, solely because of this far-sighted arrangement.

Second—A school so arranged can at any time install a plant if the power requirements increase or the local rates for current are raised.

Third—A school with boilers and piping, designed for power plant service, will have a much more serviceable equipment and a better heating installation at the most important point in the heating system, viz., where the heat is developed.

Schools, which have large power requirements and in which plants are installed, have found the following advantageous:



Fig. 128.

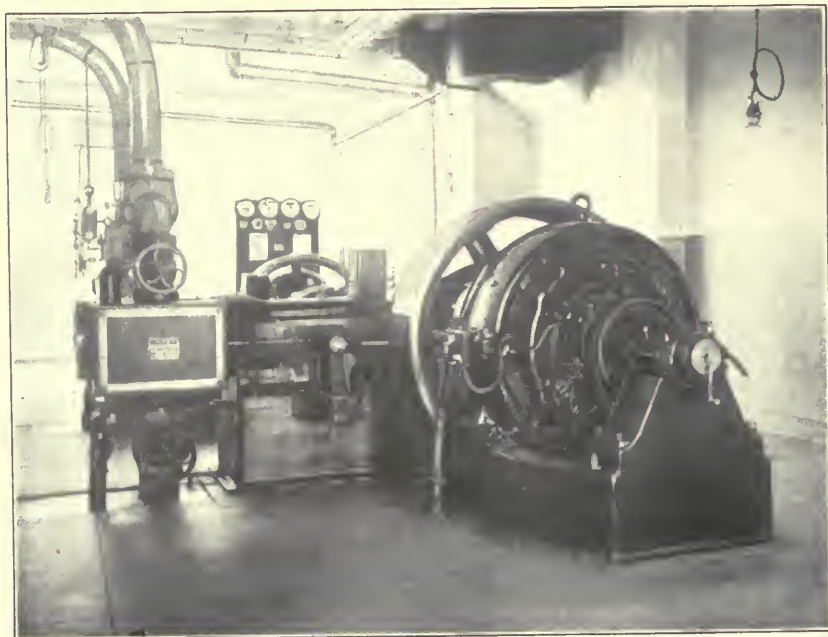


Fig. 129.

First—Current can be obtained in almost unlimited quantities with practically no additional expense.

Second—The buildings are entirely independent of outside trouble such as wires blown down, trouble at the central station, etc.

Third—No charges are incurred during summer closing.

Fourth—Current of any kind or quality can be generated whereas, with outside service, current (such as the local service company decides to furnish) must be accepted and used. Oftentimes such outside current is totally unsuited for school work.

Fifth—It is possible to have all the above advantages and still save money to a considerable extent, the exact amount depending on the local conditions.

It may be remarked that most of the current furnished by service companies is of the "alternating" variety which, while suitable for lights, is totally unsuited for school work where motors are directly connected to large ventilating fans and other apparatus is used requiring slow speed

or variable control motors. Alternating current in fact is so undesirable that in many schools a motor-generator set is installed consisting of an alternating current motor operated by outside current. This motor drives a "direct current" generator which, in turn, supplies the school. While the result attained with such apparatus is the same as if direct current were furnished by the company it is not economical. Only about 90 per cent of the energy put in at one end of the machine comes out of the other and thus the power bill is increased by about 10 per cent for which no service is rendered.

The principal reason that electric companies continue to furnish alternating current is that this current can be raised to higher voltage and therefore can be transmitted on a smaller wire than direct current. The current thus meets most economically the requirement of the service company which is the transmission of current from the central station to the point of use with a minimum loss and least cost. The consumer, however, must take it as delivered regardless of the requirements at the consuming end of the line and of his own interests.

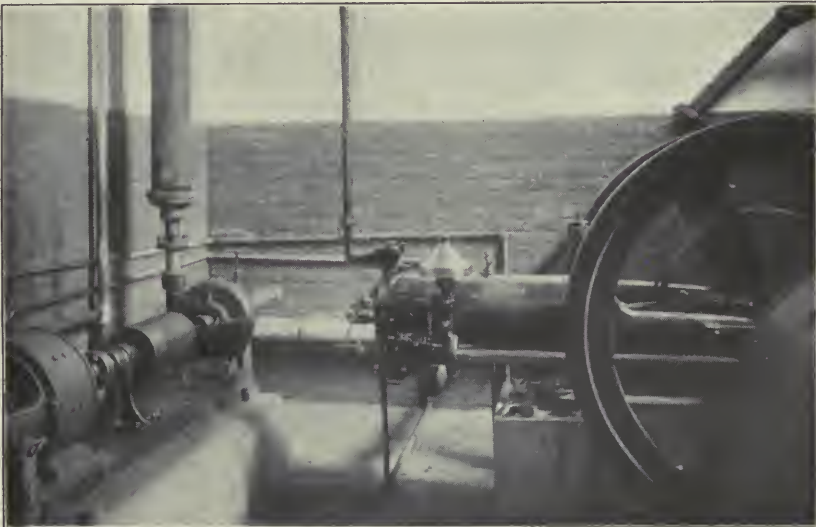


Fig. 130.

CHAPTER XV

The School Swimming Pool

Schools in which swimming pools are installed are becoming more common every day, and among the newer schools recently planned or already in process of erection, pools are the rule rather than the exception. This applies of course to buildings of reasonably pretentious character and where other facilities are similarly complete. As all indications seem to clearly point toward the increased use of pools in the years to come, it is essential that they be viewed from a proper standpoint and considered with regard to their operating cost as well as initial outlay.

Painful as the fact may be to the ardent advocate of the pool, it is undoubtedly true that

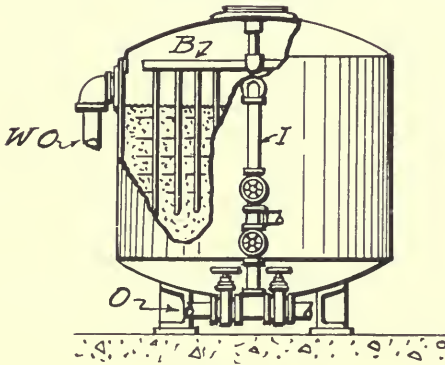


Fig. 131.

pools are far from being an unmixed blessing. They are expensive to install, require some expenditure to maintain, must be provided with one or more attendants, must be heated, should have rigid sanitary rules enforced to prevent their becoming a source of danger and, altogether, are more or less of a responsibility.

Accidents, too, have happened such as occasional drownings, diving into a pool basin after the water has been withdrawn, striking the head on the bottom when diving, etc., etc. True, such accidents are comparatively rare, yet they are not so impossible as to have already actually happened.

On the other hand the increasing popularity of the pool shows its capability for assisting hygiene by promoting bodily cleanliness—not so much with the idea of actually *washing in the pool* as by making the pool act as an inducement to take the good shower bath *required before* entrance into the pool is *permitted*. Many schools are also making their pools serve others besides the pupils of the building, each building being thrown open on evenings and Saturdays to the entire adult population of its respective district. This is falling directly in line with the increasingly popular idea of making a school, not only a place of learning, but in truth a community, or civic, center.

While accidents are indeed possible, the presence of an instructor, combined with clear water in the pool and good light will make the danger sufficiently remote to be reasonably neglected. Undoubtedly the greatest danger is from the spread of disease thru the medium of the pool water. This, if not guarded against, is indeed a most serious danger. Yet it *can* be effectually guarded against, and science has made the pool operated along modern sanitary lines entirely safe.

The simplest method of obtaining pure water in the pool and one that readily suggests itself when contamination of pool water is considered is to *run in fresh water!* This seems so simple, so efficient and so satisfactory a solution of the problem that it should be entirely unnecessary to go farther. Now, there is little to be said against such a procedure until the bills for water (and coal to heat the water) begin to come in; and the worst of it is that these bills will keep growing and growing, as the pool becomes more and more popular, until they become excessively large.

Yet facts are facts! In dollars and cents the ordinary pool costs about \$5 to heat with coal at \$5 per ton and about \$7 for water with water at \$1 per thousand cubic feet. This makes a total cost of changing the water in the pool of \$12 each time, and this brings up the question

of how many times the water must be changed in a year.

When it is remembered that with this method the water enters the pool directly from the city mains (or other source of supply) and—from the time the first user enters the pool until it is finally run off and a new change of water run in—constantly and continuously increases its bacteria and other impurities, it can be seen that a considerable quantity of fresh water must be used to dilute the impurities a sufficient amount so as to render them negligible. Actual experiments in pools operated under this plan show that about 25 gallons of fresh water are required for each bather who uses the pool, and the frequency of change, therefore, depends almost entirely on the number of users. Supposing 200 persons use the pool each day. This means 5,000 gallons of fresh water per day, or a complete change of water once every ten days. With four hundred users the pool would have to be changed every five days, etc. The average practice seems to require a change about once a week so that in a year the cost of coal and water will amount to about $\$12 \times 52$ or $\$624$ per year. And remember, with this method there is no guarantee of freedom from bacterial dangers—for while the danger is *lessened* it is not *entirely* removed by any means.

On the other hand a pool can be equipped with mechanical devices which render the use of heat practically nil and which keep the water in a purer condition than when it originally entered from the city main. So far as cost is concerned these devices can be paid entirely in three or four years out of the saving made over the cost of operation when raw water is used all the time. This plan of operation involves the use of heaters, filters, sterilizers, aeration, and a co-agulant feed into the water.

In purifying swimming pool water it has been found necessary to

(a) Inject a co-agulant which causes the impurities to lump or clot together so as to be easily strained out.

b) Strain out all coarser impurities by driving the water thru a filter just as water is filtered in nature by passing thru the porous rocks.

(c) Kill various dangerous or undesirable bacteria by means of sterilization, either by the addition of a chemical or by electrocution.

(d) Mix the water with air—called aeration—to oxidize certain bacteria and to combine minute particles of air with the water so as to make it bright and sparkling.

While these processes sound rather formidable they are comparatively simple, the co-agulant being a simple solution injected into the water on its way to the filter so as to make the impuri-

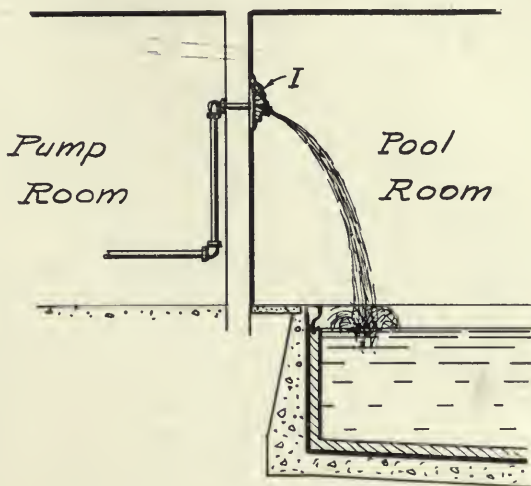


Fig. 132.

ties more easily caught thru co-agulation or the formation of larger particles. The co-agulant (usually alum is used for this purpose) is placed in a plain iron cylinder and part of the pool water going to the filter is bypassed so as to run thru the alum chamber. As a result a small part of the alum is dissolved and mixed with the pool water before it gets to the filter.

The filter is a common cast iron shell in which sand, quartz, bone black, charcoal or other medium is used and thru which the water is forced. A sectional view of a common type of filter used for this purpose is shown in Fig. 131 in which I indicates the inlet, O the outlet, B a breaker to stir up the bed and WO a wash-out pipe for running off the discharge when washing out the filter bed.

The sterilizer may be similar to the co-agulating receptacle except that hypochloride of lime is used. The sterilizer may be of more pretentious character utilizing electric current and killing bacteria by means of the ultra violet rays, similar to the process described for the sterilization of drinking water.

Aeration is secured by allowing the water to shoot thru the atmosphere. It is generally effected by spraying the water as it enters the pool or by letting it fall from some high point into the pool, as shown in Fig. 132. In this figure, I indicates an ornamental inlet such as a lion's head, etc.

Supposing this equipment is installed, how long will it be possible to retain the water in the pool and in what condition would it be at the end of the period? In answer to this the rather surprising statement can be made that the water may be used indefinitely and, more astonishing still, that the water can be maintained at even a higher degree of purity than its original natural state! In other words a pool of water after being in use constantly by bathers for even as long a period as *three years* is in a *purier state* than any natural drinking water. This has been proven by actual scientific tests on pools after such periods of use. From this it can be seen that when pools are properly installed and operated they can be maintained at such a degree of purity as to make talk of contamination a joke, except to the ignorant.

In connection with this it is interesting to note the existing practice along this line, as shown by queries sent to some five hundred pools taken at random thruout the country. While replies were received from over 50 per cent of the pools the results shown by these answers may be assumed to cover the average conditions in the United States especially on the older pools.

The answers showed that roughly,

(a) The average capacity of pools is 50,000 gallons and 94 per cent are rectangular in shape running in size from 20 x 10 feet to 140 x 65 feet.

(b) Some 68 per cent receive natural light either from skylights or windows.

(c) The average temperature maintained is about 74 degrees Fahrenheit.

(d) The pools where purity is maintained by re-filling with fresh water amount to about 66 per cent of all the pools.

(e) Out of such pools only 4 per cent refill daily, 14 per cent every other day, 18 per cent twice a week, 2 per cent every five days, 50 per cent every week, 8 per cent every ten days, 5 per cent every two weeks and one pool only every 30 days.

(f) Some 34 per cent of all the pools employ filtration of which 100 per cent filter the water entering the pool, 64 per cent use re-filtration to maintain purity, 20 per cent use lime and 2 per cent sulphate of copper in addition; another 2 per cent employ all these three methods.

(g) About 60 per cent have scum gutters.

Certain accessories accompany a pool such as shower baths, lockers, towels, suits, etc. Lockers must be provided for each occupant of the pool, and showers should be arranged for bathing purposes besides the ones installed exclusively for pool use. As a general thing the locker rooms are designed so as to be utilized either for gymnasium or pool purposes as desired. Of course where outsiders are allowed to use the pool this is not possible but where school pupils alone are to be considered such an arrangement is usually adopted.

In connection with the locker rooms and often in the same room individual showers are installed for rinsing off after gymnasium practice and for the use of those who do not desire to enter the pool. Such showers are not used in any way connected with the pool and are solely for gymnasium or other outside use.

The showers for the pool users are commonly installed between the entrance to the pool room and the pool itself; the idea being to force all users to remain at least a full minute under the shower before entering the pool. By this means the shower washes off and disposes of much of the coarser impurities which would otherwise be carried into the pool and where they would contaminate the water very rapidly.

Supposing that it has been decided to install a pool, the first thing to be determined is the location and size of the room. While it is entirely practical to install a pool on an upper floor—this having been done in more than one case—it can hardly be recommended as an economical proposition owing to the great weight of water and walls to be supported. In fact in a 50,000 gallon pool the weight of water alone approximates 250 tons. On this account the favorite pool location is in the basement where it can be set directly on the ground and no other structural supports are needed.

For a school pool where both sexes are to be served, it has proven a great success to locate the pool in the middle of the building making one end of the basement a "boys" section with the boys' lockers, showers, play room, toilets, etc.,

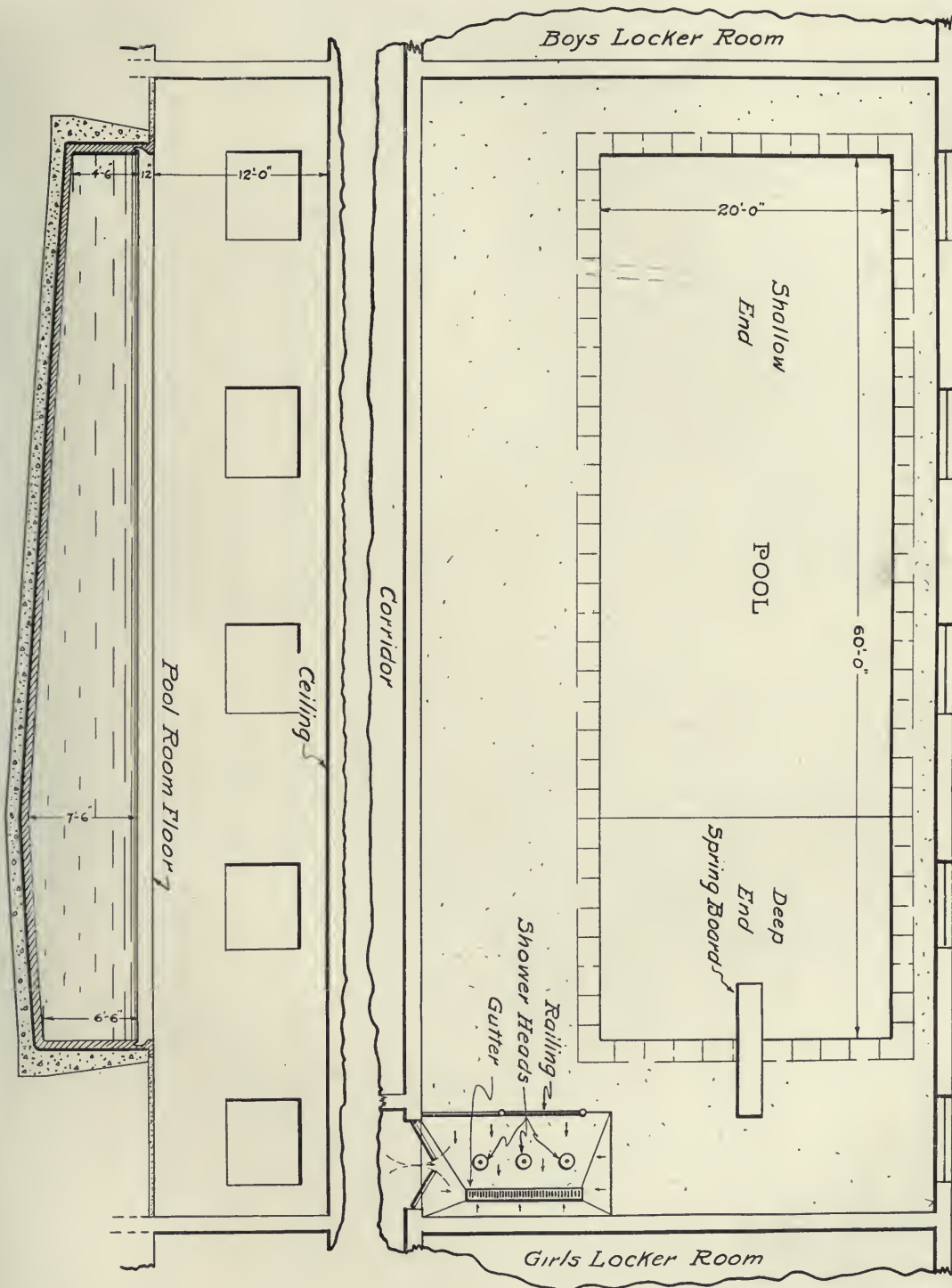


Fig. 133.

and the other end of the basement a “girls” section with similar equipment for the girls. Then, by opening a door from either side into the corridor leading to the pool, direct access for either boys or girls into the pool can be obtained as desired without danger of conflict between the sexes.

Fig. 133 shows a typical school pool of standard size, viz., 20 feet wide by 60 feet long. Usually the shallow end is made with 3 ft. 6 in., to 4 ft. 6 in., depth of water, and the deepest portion with 7 feet to 7 feet 6 inches depth. The pool showers are shown in the shape of three heads set over a gutter directly at the door entering the pool room. These heads should be controlled by a valve operated by the instructor who should see that each pupil gets a thoro drenching. It will be noted that the boys’ locker room and girls’ locker rooms are located adjacent but on opposite sides of the pool room.

The most economical way to build a pool of substantial construction consists of erecting concrete retaining walls with a reinforced concrete

bottom, thus forming the rough shell to retain the water. Concrete and other masonry, however, is not watertight by any means and on the inside of this shell must be placed a waterproof membrane to retain the water and to prevent leakage.

The waterproofing is most commonly obtained by coating the walls and bottom with hot pitch, on which are laid successive layers of tar felt, each layer being covered with a coating of hot pitch before the next is applied and all joints overlapped about eighteen inches. To protect this membrane from mechanical injury and also to form a proper base on which to erect the tile or enameled brick lining, an eight inch brick wall is built inside of the membrane along the sides and a cement floor is laid over the bottom. Then the tile, terra cotta or enameled brick lining—as the case may be—is placed to form a sanitary finish on the inner surfaces of the pool. A section of a completed pool wall is shown in Fig. 134. Here, C indicates concrete, B brick, M mortar, W waterproofing, P pool, E earth and T tile or enameled brick facing.

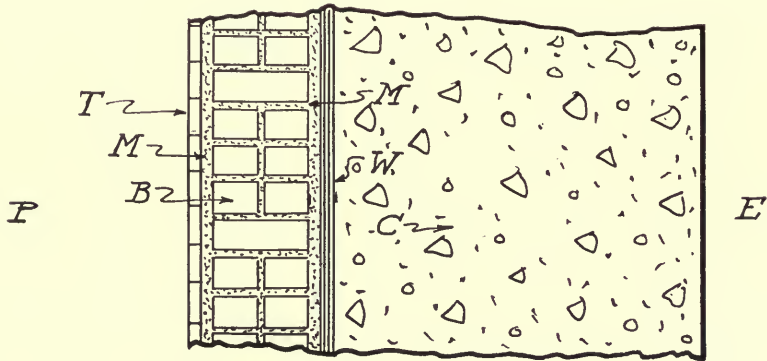


Fig. 134.

CHAPTER XVI

Pool Equipment

Having constructed a pool the next problem is the matter of supplying water to it. The most ideal water supply and one that gives water in almost unlimited quantities is an artesian well, but owing to the fact that wells are often impractical and also because cold water is always at hand for use in the toilets and showers the pool is usually supplied from the general source from which the building is supplied.

When the water enters the pool directly, the temperature is entirely too low for use and some form of heating is necessary. The simplest method is to heat it by an injector using high pressure steam and shooting the pool water mixed with the steam condensation into the pool as shown in Fig. 135, which is self-explanatory. Owing to the necessity of having steam at 30 or 40 lbs. pressure in order to operate this apparatus properly and to rather unsatisfactory results attained by this method it is little used in the new pools now being built.

Another method giving more satisfactory results is shown in Fig. 136. It consists of hot water heating boilers which circulate the water between the pool and the boilers by means of gravity. This requires that the boiler be set lower than the pool level—the lower the boilers are set the better such circulation becomes. Provided it is possible to get the condensation back to the steam boiler, a steam heater could be substituted in place of the hot water boiler shown in Fig. 136; this, however, is a very uncommon arrangement.

Having supplied the water into the pool and raised it to a satisfactory temperature, how shall its purity be assured and maintained? Shall it be used in a constantly increasing state of impurity for three to seven days (at the end of which time it must be wasted and a new supply run in) or shall it be filtered before entering and then refiltered daily, to keep it in fairly good condition?

Assuming that filters *are* to be used this immediately necessitates the use of a pump which is commonly termed a "circulation pump" to force the water thru the filters in refiltering. The best type of pump for this purpose is a centrifugal pump direct-connected to a small elec-

tric motor. A 1½ in. pump is entirely sufficient for the standard size pool.

The circulation pump takes the water from the deepest part of the pool (and from the bottom thereof, thus securing the coldest water) and discharges it thru a heater (usually of the steam type and hung on the ceiling) from which the water passes to the filter and then back to the pool. On re-entering the pool it is desirable to insert the water at two or three different points preferably at the opposite end from which the pump is drawing out the water. This results in a gradual movement of the water from the shallow toward the deep end, and prevents localizing the inflow of warm water.

If a filter is used its operation should be assisted by the use of a co-agulant feeding apparatus. This is very inexpensive and consists simply of a cast iron reservoir in which alum is placed. The amount of alum fed is controlled by allowing a smaller or larger stream to pass thru the receptacle dissolving the alum and carrying it back into the circulation line so as to mix with the circulating water going to the filter.

After leaving the filter the water should pass thru a sterilizer in order to kill the remaining bacteria. It must be remembered that the filter is in fact little more than a strainer while the sterilizer is a germicidal agent, neither being complete without the other, as it is desired to return the pool water both *clean* and *pure*. The sterilizer is also an inexpensive feature. If one of chemical type is used, it is similar to the co-agulant chamber in construction and operation except that it uses lime instead of alumf.

The arrangement of such apparatus is shown completely in Fig. 137 where the water coming from the pool goes to the circulation pump and is then discharged thru a check valve either to the sewer (if it is desired to empty the pool) or to the steam heater. If it is desired to by-pass the heater for repairs, or any other reason the valve in the heater by-pass H.B. is opened and the other two valves are shut. The water then goes to the filter and rises toward the top connection where the larger part bypasses thru C.B., the two small lines leading to and from

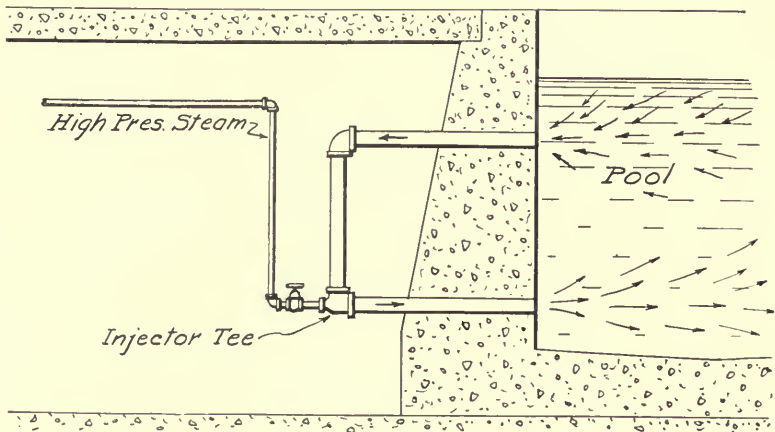


Fig. 135.

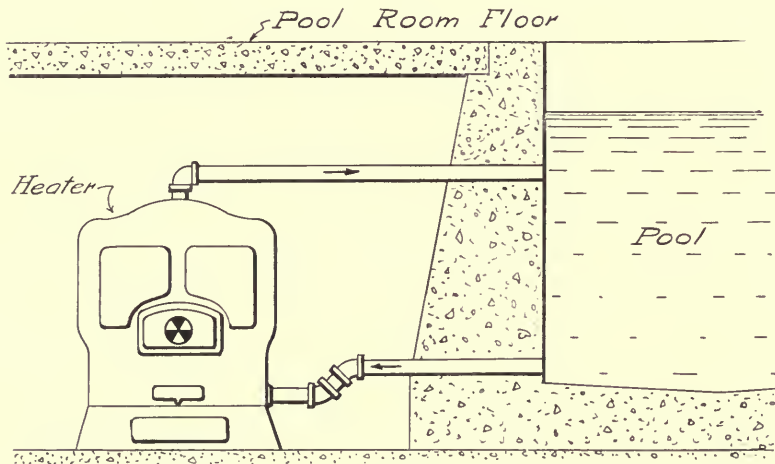


Fig. 136.

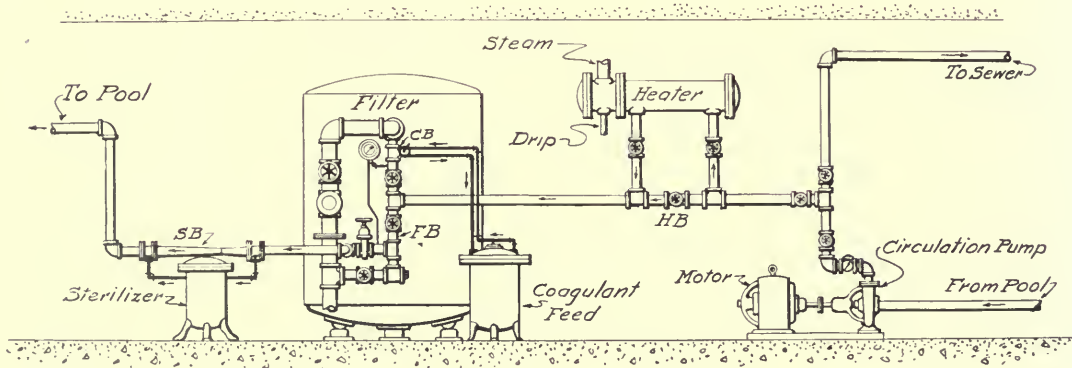


Fig. 137.

the co-agulant feed so that a small portion goes thru the co-agulant receptacle as explained. If it is desired to bypass the filter, the filter bypass FB is used, the water passing on to the sterilizer where the main portion goes thru the sterilizer by-pass SB and then back to the pool.

While this is the outfit in use in a large number of the pools where re-filtration is used, the

proper refiltration it has proved by test to be purer than the average drinking water as drawn from the faucet in the cities of the country.

Where the electric sterilizer is used a box is usually placed at some high point into which the water is pumped and then after passing thru the ultra-violet rays overflows into the pipe leading down to the pool inlet. Such an equip-

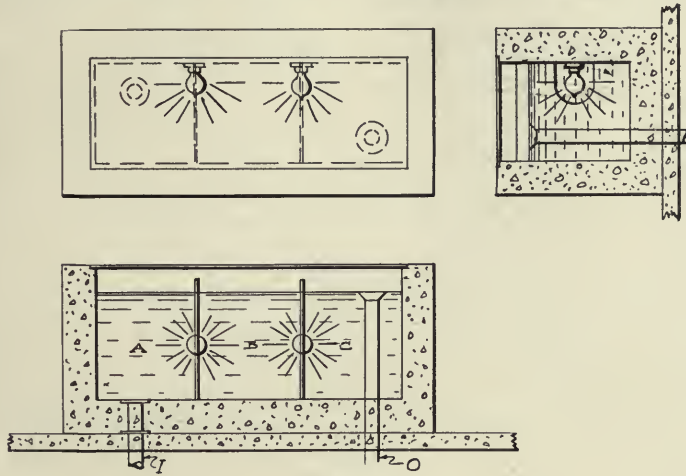


Fig. 138.

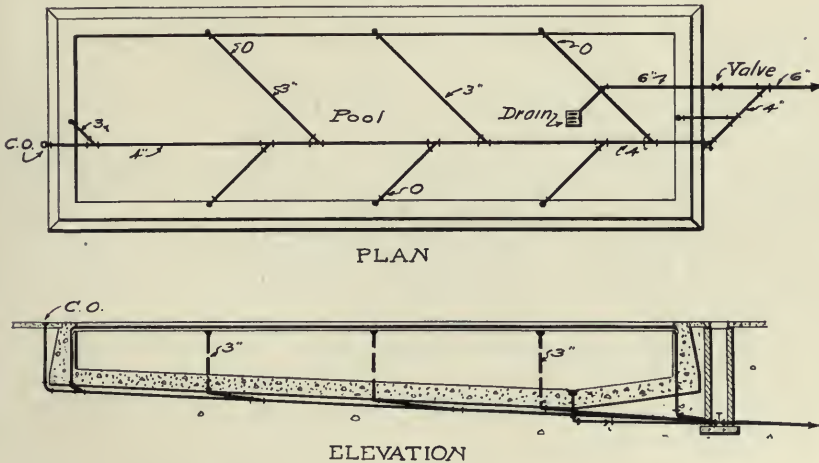


Fig. 139.

electric type of sterilizer has made such great strides in recent years and has produced results so remarkable that it deserves most emphatic recommendation. This apparatus employs an electric lamp emitting invisible ultra-violet rays to kill all germs in the pool water which is forced to flow past within the required distance of the lamp. After water has been in use sometimes for as long as three years with this sterilizer and

ment is shown in Fig. 138 where a plan view and two cross sections are given. The water is pumped into the box thru the inlet I and enters compartment A; from compartment A to compartment B the only connection is by means of a rounded opening in the middle of which opening the quartz lamp is set. To make assurance doubly sure a similar partition and lamp are placed between compartment B and com-

partment C so that the germs must twice run the gauntlet of electrocution. The water passes from chamber A to chamber B thru the opening, and then to chamber C thru the second opening. In chamber C the water overflows into the outlet pipe O which carries it down to the pool inlets.

It is also recommended that a scum gutter be provided for the pool in any case. As a matter of fact with re-filtration properly carried on there is little or no scum to take care of and water splashed into the scum gutter is lost by going down the overflow. Yet if, at any time, it is desired or necessary to operate the pool without the use of the filter, this can be done in a much better manner by using the scum gutter and overflowing the water into it.

The gutter itself is formed in sections of glazed terra cotta blocks with drain pipes connected every twenty feet or so. Its use not only frees the pool itself from scum, etc., on the surface but it also catches all drippage from the pool room floor that would otherwise run down the sides of the pool and help contaminate the water.

The piping for the overflows consists of 2 in. or 3 in. drain pipes carried down and united into a 4 in. overflow line which is carried out and connected to the pool drain beyond the drain valve. From a sanitary standpoint it is much better to carry the overflows immediately to a trap located just below the scum gutter, and in some cities this is an absolute requirement. There are manifest disadvantages to this as can be readily seen on account of the traps being located in the solid masonry walls of the pool and requiring cleanouts in the pool room floor. It is therefore common practice and is generally permissible to pipe the overflow, as shown in the plan and elevation given in Fig. 139, where O indicates overflows and C.O. cleanouts.

The valve on the drain is necessarily located below the pool bottom and should be placed in a manhole to make access possible. The handle may be extended up to a point just under the manhole cover or—if the manhole is in an unimportant position—may even be extended thru the cover with the wheel mounted above the floor.

Now as to cost: The average pool room should be about 75 ft. long, 35 ft. wide and not less than 10 ft. high; this gives a cubic footage of 26,250 cubic feet which, at 20 cents per cubic foot, means a cost of \$5,250 for housing the pool. To build a modern pit for a pool includ-

ing walls, waterproofing, enameled brick, scum gutters, etc., amounts to \$3,000 to \$4,000. The piping, valves, heater, pump, etc., will run to \$750; a filter capable of properly handling a 50,000 gallon pool about \$1,500 including coagulant feed and chemical sterilizer; an electric sterilizer will cost about as much as a filter but cannot be substituted for it.

This gives approximations as follows:

Pool without filtration—

Pool pit\$3,500

Piping 500

Pool with re-filtration plant— \$4,000

Filters\$1,500

Additional pipe 500

2,000

Pool with electric sterilization— \$6,000

Sterilizer\$1,500

1,500

\$7,500

It can readily be seen from this that even the cheapest pool is pretty expensive and a good pool is only more so. Still, if a pool is to be installed, by all means put in a good installation and do not render a questionable service to the community by providing a disease carrier and germ developer in its midst.

All boards operating pools in their schools will do well to follow the nine commandments laid down in a paper recently read before the American Association for Promoting Hygienic and Public Baths. They are as follows:

1. Maintain the water in the pool pure and clear; employing both refiltration and chemical disinfection.
2. Have the pool well lighted; natural light by day—sunlight when possible.
3. Keep an attendant always on duty when the pool is in use; prohibit admission at other times; allow no one to enter the pool alone.
4. Maintain a strict supervision of the bathers, medical examination if practicable; preventing persons with communicable diseases from entering the pool.
5. Enforce the scrubbing of each bather before entering pool.
6. Prevent all clothing or provide sterilized clothing.
7. Surround the pool with a scum gutter and prevent expectoration in or about the pool.
8. Prevent visitors carrying dirt and disease germs on their footwear into the pool room.
9. Do not have any obstruction in the pool, or along the edge of the pool, nor adjacent to the pool.

CHAPTER XVII

Electric Lighting

The importance of providing for the proper lighting of classrooms is one which should not be underestimated. The need of illumination for day classes on dark days and the requirements of night schools both combine to render satisfactory lighting an essential of schoolhouse planning and equipment. It is not within the province of this discussion to argue the peculiarities of the eye, or the diseases resulting from a lack of proper or sufficient lighting. These topics are distinctly within the province of the school hygienist, the physician and the oculist. It may not be out of place, however, to note that the eyes of average pupils are subjected to their first concentrated use in the schoolroom and that the eyes of children of school age are only in the transitory period of growth succeeding babyhood and are far from possessing the visual strength which is acquired in later life. Eye troubles developed during this time are likely to become chronic weaknesses later and should be carefully guarded against.

There are in all some twenty-one million school children in the United States of whom not less than two million are troubled by defective vision. Of course, this is a dry and statistical statement. Yet the fact is conducive to thought, even tho it does not necessarily follow that these two million pupils are visually defective on account of poor light in the schools. Some children develop eye troubles before entering school and still others abuse their eyes by overstudy or by other means for which the schools could not possibly be held responsible. But admitting that the trouble is there, it certainly should not be aggravated in the classroom where the school boards are responsible.

Artificial illumination has always been designed with the idea of producing a condition approximating sunlight. How poorly such an approximation really is (when obtained from various sources of artificial light) the reader is fully aware of, yet the modern systems of lighting more nearly approach such an ideal condition than any methods previously developed.

The natural lighting of the modern classroom has worked down to a fairly consistent design in

which the windows equal in area 14 to 25 per cent of the floor area and are arranged on the left-hand side. It has been recommended by experts on illumination that the depth of classrooms (perpendicular to the window wall) should not be greater than twice the height of the window above the top of the desks; also that the walls be light colored and the ceiling white. With such design the most satisfactory results will be obtained, and the light walls and white ceiling will also assist the artificial illumination.

Other items also enter into the matter of making artificial light satisfactory. Installations, perfectly correct so far as design may be concerned, will give considerable trouble and result in much unnecessary eye strain if other matters are not made to harmonize with the end in view. For instance, the use of highly glazed paper in the school books is bound to fatigue the eye in a very short time, regardless of the arrangement of the lighting. The size of type, the spacing of lines, the color of print and paper similarly affect the eye. Still worse, is the constant reflection from highly polished desks, glazed walls and glazed blackboards.

The development and perfecting of the tungsten filament for the incandescent electric light have revolutionized lighting in the last few years. The tungsten lamp has produced a whiter light, far more nearly approximating sunlight than the old carbon filament. It does this at a cost of about 31 per cent of what the old carbon filament required, when compared candle power for candle power. It has made commercially practical the "indirect" method of illumination which, while vastly superior to the old direct style, is not as *efficient* a method of illumination. That is to say, it takes *more* current for indirect lighting but the rays are so diffused as to make such lighting very desirable.

There are three general methods of lighting consisting of:

(a) *Direct* illumination, in which the light shines directly on the surface illuminated.

(b) *Indirect* illumination, in which the source of light is entirely concealed by a shade and the

illuminating effect is secured by reflection from some white diffusing surface which is usually the ceiling, and

(c) *Semi-direct* illumination, in which the majority of the light is indirect but a portion of the shade is made translucent so that the balance is "direct," but well diffused.

Diffusion of light is accomplished by breaking up the rays of light emitted from one or several sources so as to have a more even light of lesser brilliancy emitted from a larger area than the prime source. A clear glass globe gives practically no diffusion but the same globe in frosted glass diffuses to a very satisfactory extent.

In Fig. 140 is shown a standard type of direct lighting fixture which is inexpensive and of good design. In this case a glass, metal or porcelain reflector may be used and the rays of light from the lamp are thrown directly down onto the floor and furniture. The use of this fixture in long corridors, stairways, wardrobes and similar circulation passages, where the lights are almost always burning but where no one's eyes are exposed to the light for any long period of time, is recommended owing to the high efficiency of the direct light.

Fig. 141 is a similar fixture with a bowl of translucent glass which tends to diffuse the light to a great extent. This fixture is recommended for such rooms as the principal's main office, waiting room, medical examination room and similar locations where pupils or instructors may have their eyes subjected to the light for longer periods.

Fig. 142 is a frosted or semi-transparent shade covering lights where the headroom is low as under stairways, etc., and where longer fixtures would be in the way.

Fig. 143 indicates a fixture with an opaque metal reflector that throws all the light up to the ceiling from which it is reflected downward. This is the common type of indirect fixture and is recommended for classrooms, art rooms, dress-making, typewriting rooms, etc., including all places where pupils are likely to be subjected to artificial light for long periods. Its chief disadvantage consists of the rather dark and gloomy appearance of the under part of the reflector.

Fig. 144 shows a type of semi-indirect fixture in which the illumination of the glass bowl results in some light passing directly downward while the balance is reflected onto the ceiling by the bowl the same as in the indirect fixture just discussed. This fixture is recommended where the cost of current is an important feature. With less current consumption, the lighting results of this fixture are almost as satisfactory as with the purely indirect fixtures.

Besides the ones illustrated, there are other derived variations and designs for fixtures *ad infinitum*. All are based on the types of fixtures shown and on combinations thereof. Many such fixtures possess real merit but it is impossible to discuss all here. Their characteristics are largely the same or similar to the typical fixtures already cited.

After the question of fixtures is decided the matter of their location becomes imperative. Usually school authorities do this backwards; that is, they locate the outlets long before they know what kind of fixtures will be purchased. Be this as it may, the outlets must be located when a building is built and—right or wrong—they are therefore located.

It has been proven by experience that for the standard sized classroom measuring up to 24 ft.

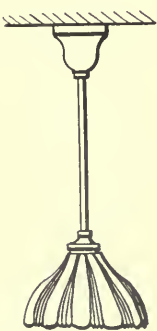


Fig. 140.

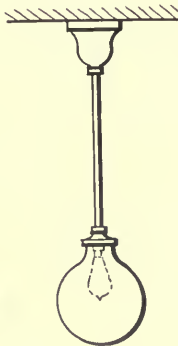


Fig. 141.

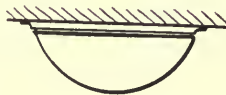


Fig. 142.

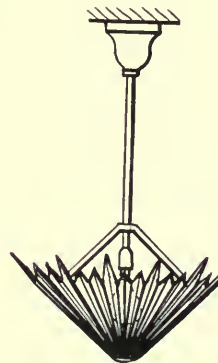


Fig. 143.



Fig. 144.

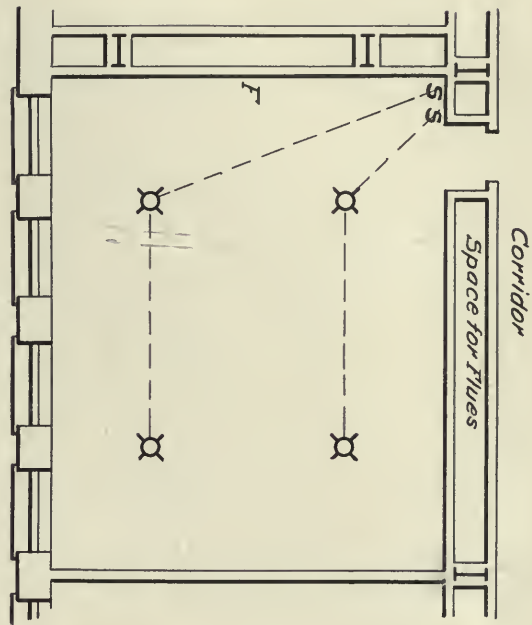


Fig. 145.

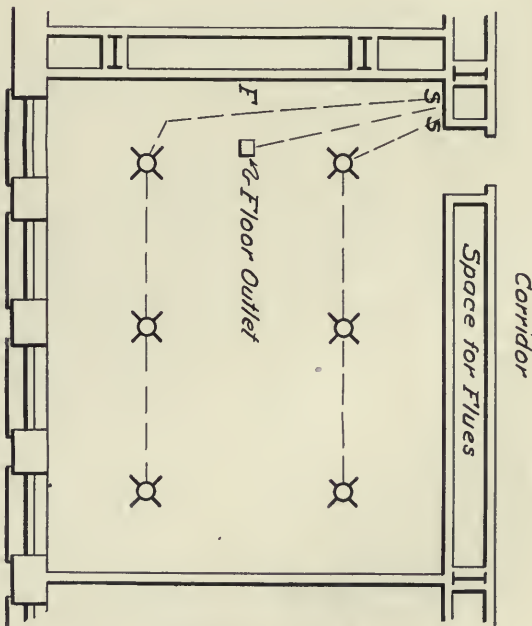


Fig. 146.

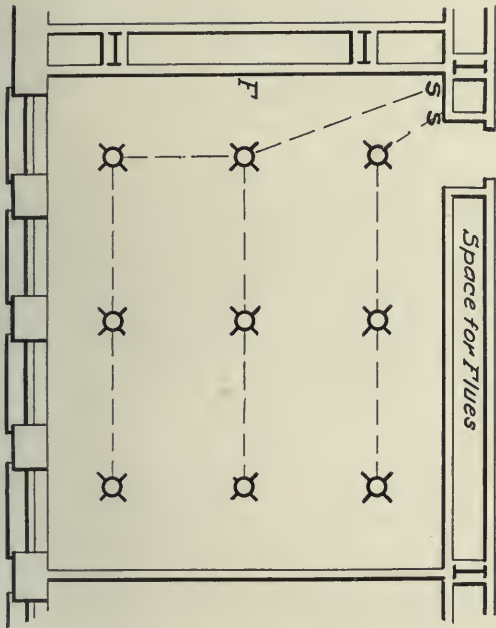


Fig. 147.

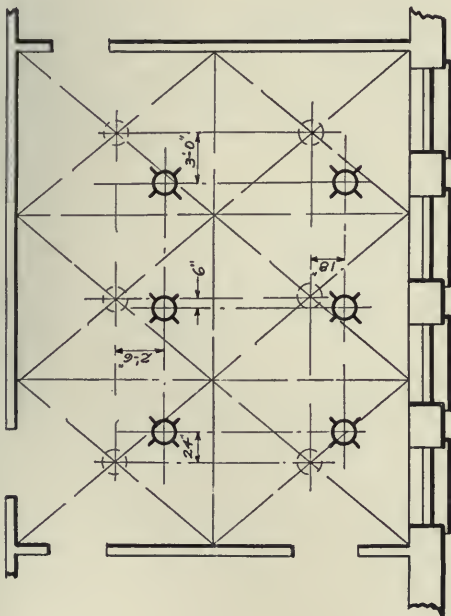


Fig. 148.

by 32 ft., or thereabouts, four outlets will give fair, six good, and nine excellent results with direct illumination. With the four outlets, 150-watt lamps are generally used, giving 600 watts for the room. With six outlets, 100 watts are usually installed giving 600 watts for the room. With nine outlets, lamps of 60 watts each, or 540 watts, are sufficient. Philadelphia, New York and Boston use nine outlets, and twelve are unusual but not unknown. With direct lighting the effect of nine 60-watt lamps is much casier on the eyes than six 100 or four 150-watt lamps, as the nine outlets distribute the sources of light and render the illumination more even. With indirect fixtures four outlets should be enough, but the new gas filled lamps of 200-watt size should be used. As a general thing when outlets must be installed before the kind of lighting is decided upon six outlets are adopted, these being very satisfactory for direct fixtures and ideal for indirect or semi-indirect work.

It might be explained parenthetically here that common tungsten and carbon filament lamps raise their filament or incandescence in a vacuum of more or less perfect intensity. The lamps known as "gas filled" raise their filaments to incandescence with the aid of a gas, inside a gas-tight bulb; hence the term "gas filled." Gas filled lamps are entirely too bright for direct lighting, being used in the larger unit sizes, for indirect and semi-indirect fixtures. One 150-watt vacuum bulb is generally considered as approximating one 100-watt gas filled lamp.

From this it can be deduced that the current per classroom for various combinations will run about as follows:

<i>Method of Illumination</i>	<i>Type of Bulb</i>	<i>Approx. Watts Per Room</i>
Direct Lights	Vacuum Tungsten	600
Indirect or	Vacuum Tungsten	900
Semi-indirect	Gas Filled Tungsten	800

This means that while indirect lighting adds over 50 per cent to the candle power, gas filled bulbs cut the current per candle power to about 50 per cent, thus making the actual increase in current consumption over direct lighting only about 30 per cent. With indirect and semi-indirect illumination it is necessary that the fixtures be installed so as to bring the top of the glass approximately three feet from the ceiling in rooms eleven to fourteen feet high.

It should be pointed out here that while indirect and semi-indirect fixtures approximate ideal lighting they have certain objections peculiar to school work. The objections have been regarded so seriously as to prohibit their adoption in at least one case, viz., New York City, and there are others who have had similar troubles.

These faults mainly lie in the fact that the pupils find the fixtures good receivers for paper wads, erasers, pencils, rubbers, waste paper, etc. Difficulty is also experienced in making the janitors keep the bowls clean, as these are concealed from view, and very rapidly collect dust. This dust, if not removed obscures the light to such an extent as to reduce the efficiency 50 per cent.

For the proper location of outlets the room should be divided into as many rectangles as outlets, and an outlet should be placed in the center of each rectangle. Some school boards make it a practice to set the lights slightly off center—toward the windows—so as to have the artificial light rays fall on an angle somewhat in imitation of the natural rays of light from the windows. It is of course impossible to actually produce enough change of angle to be of any importance and the location of the outlets in such unbalanced positions makes a very bad appearance in the room. One economy which every board may practice is that of putting the row of lights along the windows on a separate switch. There are many dark days when there may be plenty of light adjacent to the windows but not farther away. In this case the farther outlets only are used. The lights along the windows are on a second switch and are used only at night and on very dark days.

The arrangement of outlets for a classroom having four lights, together with the wiring and switches for the same, is shown in Fig. 145. The more common six light classroom is shown in Fig. 146 which also indicates a floor outlet for the teacher's desk. The room with nine outlets is shown in Fig. 147, but this arrangement is seldom used. In all cases the lights in the coat rooms should be on a separate switch. Where two coat rooms are adjacent one light can be made to do for both by using a dwarf partition and installing the light high and directly over the partition.

It has also become the practice in some cities to place a floor outlet under the teacher's desk

to allow for the use of a desk lamp, if desired. In such cases the outlet is made in a box, flush with the floor, into which an extension cord for the desk lamp is plugged. Such outlets are installed only with direct lighting. In some schools in which visual instruction is emphasized a wall plug is provided in the rear of the room for a small stereopticon.

In corridors, of course, illuminating requirements are not so exacting, being only one-third to one-fourth the requirements of classrooms, and outlets are seldom spaced over 40 feet apart. Usually 100-watt lamps are employed spaced about 30 feet apart. Shorter spacing and smaller units (60 watts or less) will give more uniform light than longer spacing and higher powered lamps, but the first cost is greater.

In lecture rooms the light should be particularly good at the front of the room where experiments will be carried on and at the rear an outlet of 5,000 watts capacity is usually provided for stereopticon use.

It is also a good idea in locating wall switches to place them six feet from the floor to prevent their manipulation by the younger pupils.

For those interested in the eccentric location of outlets for classrooms the plan shown in Fig. 148 is given. Here the normal locations of a six light arrangement are shown in dotted lines and the eccentric locations are indicated in full lines, the distance between the normal centers and the modified centers being given in each direction.

CHAPTER XVIII

Vacuum Cleaning

The newest mechanical equipment to be almost universally adopted for school use is that for vacuum cleaning. The modern vacuum cleaning machine is a distinctly recent development and because there are comparatively few buildings in which vacuum cleaning has been installed for any great length of time, there is but little practical data on the subject. The results obtained depend largely on the individual operator, and few school boards have enough machines in service to give any fair comparison between them. Still fewer school boards have made any effort to compare the results which have so far been reached. While much testing has been done by the individual manufacturers of the various makes of apparatus their conclusions cannot be accepted as wholly unbiased, and with the exception of tests made by the federal government there is little data of dependable nature.

Some information on the use of vacuum cleaning in schools has been collected by the author and will undoubtedly be a help to those who are not familiar with this kind of equipment.

In the first place vacuum cleaning, as its name implies, is a system of cleaning by means of a vacuum—partial vacuum would be more correct—and is suitable for the removal of dust, smaller particles of refuse and other material such as sand, small nails, matches, splinters, etc. This removal is effected without causing the slightest dust to fly and settle at some other objectionable point.

In order to operate such a system a vacuum producer (or machine), a system of piping, a flexible hose, and various cleaning tools are necessary. The vacuum producer exhausts the air of the piping system thus producing the required degree of vacuum. The flexible hose connected to the various outlets on the pipe lines serves to carry the vacuum from the pipe outlet to the desired cleaning point, and the actual removal of the dirt is accomplished by the cleaning tool attached to the end of the hose.

The theory of operation is that the pressure of the atmosphere (which is about 14 pounds per square inch) tends to drive the air into the

end of the cleaning tool where the vacuum opening is located and thus to diminish or entirely break the vacuum. As the machine on the other end of the piping is constantly withdrawing the air, the vacuum, however, is not entirely broken by the continuous rush of air. The constant continuance of this action makes possible cleaning by vacuum.

If the vacuum opening in the end of the tool is laid against a piece of carpet, rug, or even the bare floor the obstruction acts as a plug and causes the air to enter the opening thru every possible leak either around the opening or thru the material itself. During its passage into the tool the air engages every particle of loose dust and dirt in the neighborhood of the opening. The action is much like the winter wind blowing the ground clear of snow in spots where the fury of the gale is concentrated. Vacuum cleaning, however, will not remove ink spots, stains, grease or other similar uncleanness; it is able to carry only loose particles of dry matter.

Vacuum cleaning systems are generally classed as "high" vacuum or "low" vacuum, according to the degree of vacuum maintained by the machine, and as "large volume" or "small volume," according to the amount of air handled per "sweeper." The size of the plant is based on the number of "sweepers" or tools which the machine can operate effectively at one time. Thus a "two sweeper" plant can operate two tools run by two different men from any two outlets desired, but will not be able to remove the air as fast as three sweepers would admit it. Three sweepers on a "two sweeper" plant would result in a loss of vacuum on the whole system to so great an extent as to put all the tools out of commission. The effect is the same as putting too many faucets on a small water pipe resulting in a great loss of pressure when all are opened and a consequent reduction in the amount of water delivered by each.

A "high" vacuum plant is one which operates at a vacuum equal to about 10 or 12 inches of mercury (5 pounds per sq. in. less than atmosphere) while a "low" vacuum system operates on about 5 or 6 inches of mercury (2½ pounds

per sq. in. less than atmosphere). While high vacuum is more effective for thick carpets, rugs, upholstery, etc., it has little, if any, advantage for bare floor cleaning.

An excellent form of tool for bare floor work is shown in Fig. 149. It is provided with slots to prevent the pads from sticking too tightly to the floor on account of the vacuum suction. To get into corners a rubber pointed tube which is equally efficient to clean desk boxes, pigeon holes and other small places is used. The holders for the tools are generally of aluminum and are hollow, so that the air and dirt passes thru the handle to the hose connected at the upper end. The size of the hose may be $1\frac{1}{4}$ inch, but $1\frac{1}{2}$ inch is better as it reduces the friction loss—an important factor in low vacuum systems.

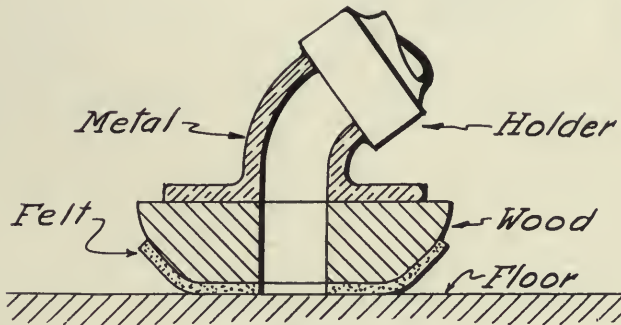


Fig. 149.

The piping for vacuum cleaning must be run so as to have outlets at certain convenient points. These points are located on the various floors directly over one another so that one vertical riser will serve one or two outlets on each floor without any horizontal piping. As a typical example the plan of the small school shown in Fig. 150 may be taken to determine the location of the vacuum cleaning outlets. In the drawing, C indicates classrooms, A auditorium, O office, TR teachers' room and T toilet.

Beginning at the lower lefthand corner a circle can be swung with a fifty foot radius (the desirable length of hose) the center of the circle being at the vacuum cleaning outlet V. C. O. No. 1. It is found that this circle will not cover the entire lefthand end of the building so another outlet, V. C. O. No. 2 is placed so that its 50 foot radius will cover the balance of this end of the building. Similar outlets V. C. O. No. 5 and V. C. O. No. 6 are located

on the opposite side of the building. This arrangement still leaves the middle portion beyond reach of the hose. Therefore, outlet V. C. O. No. 4 is placed in the corridor on the center line of the building, and the radius from this outlet covers the balance of the building.

Theoretically these outlets would be sufficient but they must be tested out for the location of doors to see that the hose will reach when run around the actual path which it must follow. On outlet No. 1 it is found that the hose will not quite reach to the extreme corner of the lower lefthand classroom; but the distance is so small that the tool length (4 ft. 0 in.) may be counted upon to cover the dotted space. A similar laying out of hose thru the offices O and the toilet T from outlets Nos. 1 and 2 shows no trouble; but on outlet No. 4 it is found impos-

sible to get into the auditorium A. Neither will hose run from outlets Nos. 1 or 6 cover it. Consequently another outlet in the auditorium (No. 4a) is necessary to cover the dotted portion shown. Had the auditorium been provided with a door near outlet No. 4, the hose could have been run thru the door and outlet No. 4a omitted. Trouble also develops in the rear classroom between outlets No. 4 and 5 but the portion not covered (shown dotted) is so small that the length of tool may again be considered sufficient to make up the required distance.

In the basement (Fig. 151) the lines are connected together into a main fitted with cleanouts, (C. O.) and to the vacuum cleaning machine. In the machine the air and dirt are separated, the air escaping usually into a flue or outdoors, but sometimes, on small machines, into the basement itself. The piping should all be black iron with recessed screwed drainage fittings to avoid clogging. The cleanouts should

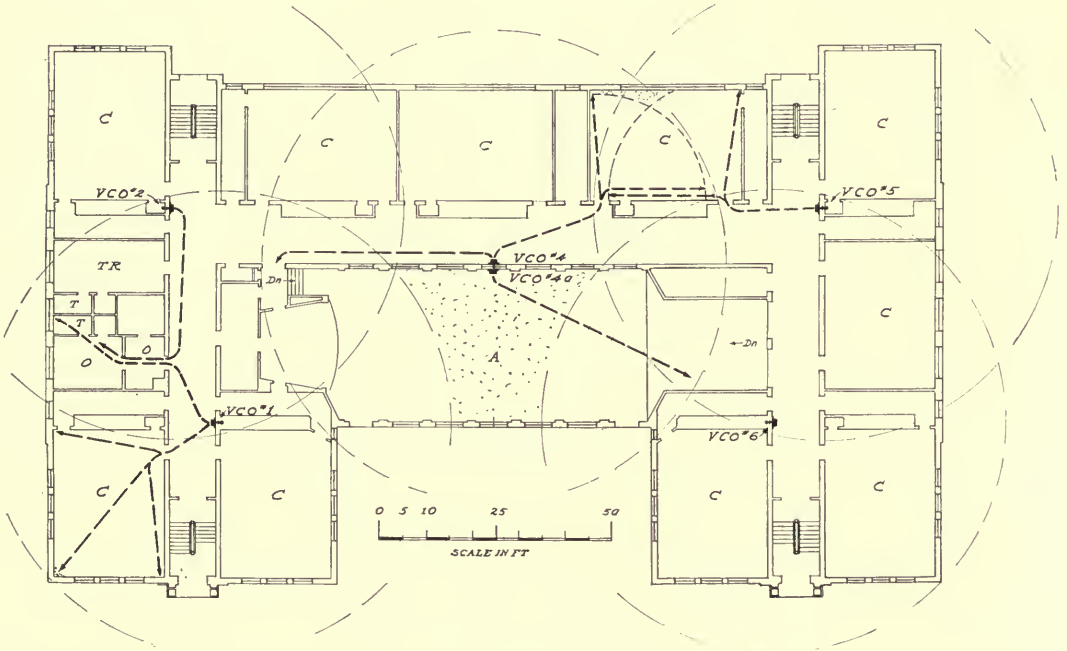


Fig. 150.

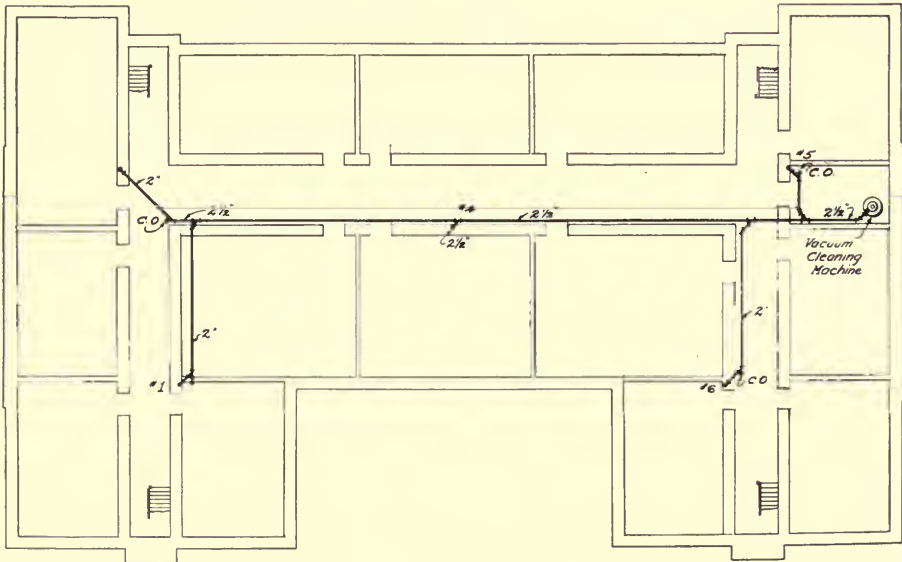


Fig. 151.

be brass plugs screwed into the pipe fittings. It is also a good plan to have cleanout Ys' in any long straight run say at fifty foot intervals to permit easy access in case of trouble. Flanges as shown at "FLG," Fig. 152 also permit disconnecting when desired.

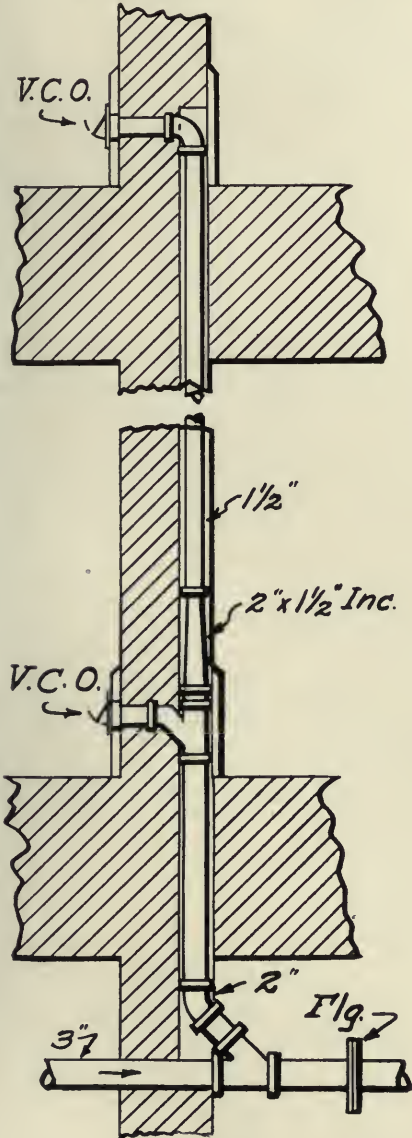


Fig. 152.

The elevation of the typical riser shown in Fig. 152 shows how the piping is run to the upper floor, picking up the first floor outlet on the way down. Some engineers advocate that

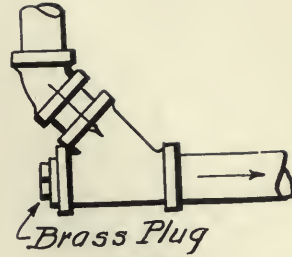


Fig. 153.



Fig. 154.

no riser or main be less than 2 1/2 inches in size so that matches cannot become lodged cross-wise in the pipe as they are liable to in the smaller sizes.

In putting in vacuum cleaning piping several points should be kept in mind: Install cleanouts as shown in Fig. 153 but never as in Fig. 154, as the dirt will be thrown into the plug pocket collecting there and gradually building up a stoppage in the pipe. Never joint two branches with a "bull-head" tee as shown in Fig. 155, nor even with a double Y as shown in Fig. 156 as the air will throw the dirt into the opposite branch so as to plug it up. Instead, use two Y's as shown in Fig. 157. Always joint a branch to the main with a Y as shown in Fig. 158 but never with a tee as shown in Fig. 159; also see to the very important point of having every pipe carefully reamed before erection to avoid burrs which will catch lint and dust.

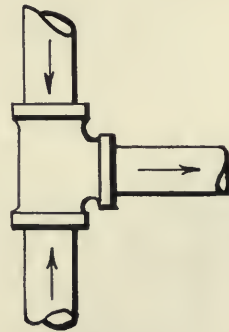


Fig. 155.

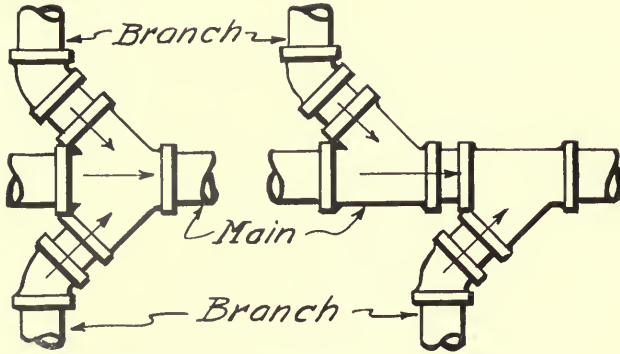


Fig. 156.

Fig. 157.

Where outlets are put in for basement use they are below the level of the main and must pull the dirt up to the level of the main. This is entirely practical but the basement drop pipes must be connected so that the dirt passing thru the horizontal line cannot fall into it. A connection like that shown in Fig. 160 should never be made. Either connect the basement pipe *back* of the upper floor riser or bring it into the main sideways so that dirt will not drop down as it passes in the main.

It is impossible in a discussion of this kind to recommend any particular machine for school use as there are several good machines on the market. The most practical method for a board to use is to decide upon the number of sweepers they will want operated at one time and then to receive manufacturer's proposals as to the details of their particular apparatus, power consumption under full load, cost, etc. This gives the greatest opportunity to get a good machine at the lowest cost and will permit any manufacturer to compete.

In order to determine how many sweepers are necessary something must be known of what

can be done with one sweeper. On bare floors vacuum cleaning is much more rapid than with carpets and an ordinary schoolroom can be cleaned in about fifteen minutes so that eight classrooms could be easily cleaned by one man after school sessions. It can also be assumed that the corridors, special rooms, etc., can be cleaned during school hours. Therefore, the sweeper capacity will run close to one for every eight classrooms or fraction thereof.

Another way to figure is that a good operator can clean 4,000 sq. ft. per hour. Allowing $2\frac{1}{2}$ hours for cleaning after sessions, would give $4,000 \times 2\frac{1}{2}$, which equals 10,000 sq. ft. per sweeper capacity.

The cost of vacuum cleaning systems varies widely with the type of machine, length of runs, etc. As an idea it might be said that a one sweeper plant with piping, tools, etc., will cost in the neighborhood of \$1,500, a two sweeper, \$1,800 and a three sweeper, \$2,100.

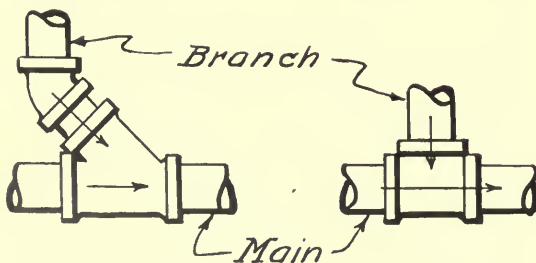


Fig. 158.

Fig. 159.

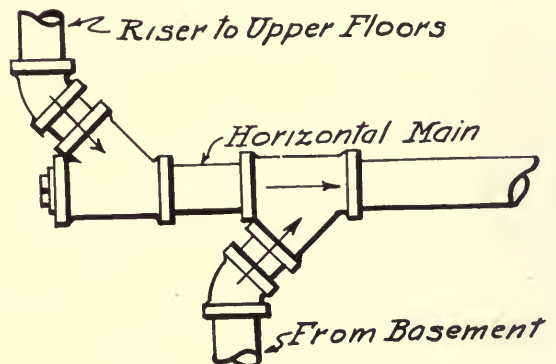


Fig. 160.

INDEX

- Aeration, Swimming Pool, 93
- Air, Composition of, 8; Pressure Unbalanced in Rooms, 25; Standard for Lunchroom, 31
- Air-Motor for Temperature Regulation, 22
- Air-Washer, 10
- Alberene Stone Fixtures, 34; Partitions, 48
- Alternating Current, 89
- Ammonia Systems of Refrigeration, 74-76
- Architects, 7
- Argentine Glass Partitions, 48
- Arrangement of Lighting Outlets, 102; Pool Equipment, 95; Shower Bath Stalls, 52; Toilet Room Fixtures, 46; Vacuum Cleaning Outlets, 105-108
- Artesian Well, 95
- Artificial Illumination, 99
- Assembly Room, Ventilation of, 19
- Auditorium Radiators, 21
- Auditorium, Ventilation of, 19
- Automatic Sprinkler System, 68-71
- Automatic Temperature Regulation, 22-24
- Bacteria, 78-82
- Basement Toilet Rooms, 44-46
- Baths, Shower, 93
- Boilers, 86-87; Hot Water Heating, 95
- Bottom-feed Water System, 59
- Breathing Walls, 17
- Bubblers, 41
- Carbonic Acid in Air, 8
- Centrifugal Pump, (Pool), 95; (Water), 59
- Chemical Fire Extinguishers, 71-80
- Chemical Fume Exhaust, 30
- Chemical Laboratory Hoods, 30
- Chemistry Laboratory, Ventilation of, 28
- Circulation, Down-feed System of Hot Water, 61; Forced Hot Water, 67; Up-feed System of Hot Water, 61-63
- Circulation Pump for Drinking Water, 76; for Pool, 95
- Classrooms, Location of Air Registers in, 10-12; Natural Lighting, 99
- Cleaning, Vacuum, 104
- Cleanouts, Vacuum, 105-107
- Closet, Local Vent, 36; Partitions, 48-50; Range, 35; Syphon Jet, 35; Wall Hung, 37; Wash-down, 35
- Cloth Filter, 10
- Coke Screen, 9
- Compartment, Shower Bath, 50-52
- Cooking Sinks, 42
- Cooling Water Tank, 75
- Conditions of Swimming Pools in the United States, 93
- Construction of Swimming Pools, 93-94
- Contact Sewage Disposal System, 78
- Control of Water Temperature, 66
- Control, Thermostatic, 24
- Corridors, Illuminating, 103
- Co-agulant, 91
- Co-agulant Feeding Apparatus, 95
- Cost of Pool, 98; Power Plant, 84; Power Plant Operation, 85; Swimming Pool Operation, 90-91; Vacuum Cleaning Systems, 108
- Current, Alternating, 89.
- Damper Regulator, 24
- Damper, Revolving, 21; Air Mixing, 13-14
- Diffusion of Light, 100
- Direct Illumination, 99
- Direct Lighting Fixtures, 100
- Disposal Field, Sewage, 81
- Disposal System, Contact, 78; Intermittent Filter, 82-83
- Double Duct Systems, 13-14
- Down-feed System of Water Circulation, 61
- Down Supply Systems of Ventilation, 21
- Drain Boards on Kitchen Sinks, 42
- Dressing Room, Shower Bath, 50
- Drinking Fountains, 40-41, 77
- Drinking Water, 73
- Duct Systems, 13-18
- Economy of School Power Plants, 84-87
- Electric Current, 84
- Electric Sterilizers (Water), 97-98
- Electric Power, 84
- Enameled Iron Fixtures, 34
- Engineers, 8
- Engines, 87-88
- Exhaust and Oil Separator, Free, 86
- Exhaust, Chemical Fume, 30
- Exhaust Outlet in Toilet Room, 25; in Classroom, 10-12; in Assembly Halls, 19; in Lunchroom, 31
- Extinguishers, Chemical, 71-80; Fire, 71-72
- Fan Room Arrangement, 9
- Fans, Toilet Exhaust, 25
- Faucets, 40
- Fields, Sewage Disposal, 81
- Filters, 57; Coke, 9; Cloth, 10; Intermittent Sand, 78; Percolating, 78; Pool, 91-95; Pressure, 57
- Fire Extinguishers, 71-72; Chemical, 71-80
- Fire Hose, 68
- Fire Protection, School, 68
- Fire Pump, 71
- Fixtures, Arrangement of Toilet Room, 46; Direct Lighting, 100; Location of Lighting, 100; Location of Plumbing, 43; Number of Plumbing, 43-44; Objections to Indirect and Semi-indirect Lighting, 102; Selection of Plumbing, 32-35; Semi-indirect Lighting, 100; Toilet Room, 28
- Flexible Hose (Vacuum), 104
- Floor Outlets, Lighting, 102-103
- Flucs, 17; Toilet Exhaust, 25
- Flushing Devices, 36
- Flush Valves, 36-37
- Forced Circulation of Hot Water, 67
- Fountains, Drinking, 40-41, 77; Pedestal, 41; Wall Hung, 41
- Free Exhaust and Oil Separator, 86
- Galvanized Iron Fixtures, 34
- Gang Shower, 67
- Gas Heaters, 63
- General Considerations of School Swimming Pool, 90
- Generators, 86; Motor Set, 89
- Gravity Tank, 36, 54-57; Fire, 71
- Gravity Ventilation, 17-18
- Gutter, Scum, 98
- Heaters, Gas, 63
- Heating, 8
- Heating Plant, High Pressure, 84; Low Pressure, 84-86
- Heat, Steam, 84
- High Pressure Heating Plant, 84

- High Vacuum Cleaning System, 104-105
 Hoods, Chemical Laboratory, 30-31; Kitchen, 30-31
 Hose, Flexible (Vacuum), 104; Fire, 68
 Hose Rack, 70
 Hose Valve, 70
 Hot Water Heating Boilers, 95
 Hot Water Systems, 61
 House Pump, 87
 House Tanks (Water) 59

 Illuminating Corridors, 103
 Illumination, Artificial, 99; Direct, 99; Indirect, 99-100; Semi-indirect, 100
 Importance of Proper Lighting of Classrooms, 99
 Indirect Illumination, 99-100
 Individual Duct Systems, 13-17
 Individual Shower Bath Stall, 50
 Injector, 95
 Intermittent Filter, Sewage Disposal System, 82-83
 Intermittent Sand Filter System, 78
 Iron, Enameled Plumbing Fixtures, 34; Galvanized Fixtures, 34

 Kitchen and Slop Sinks, 41
 Kitchen Ventilation, 30

 Lamps, Tungsten, 99
 Lavatories, Vitreous-Porcelain, 40
 Lecture Room Lighting, 103
 Light, Diffusion of, 100
 Lighting Fixture, Direct, 100; Indirect, 100; Semi-indirect, 100
 Lighting, Lecture Room, 103
 Lighting of Classrooms, Importance of Proper, 99; Natural, 99
 Lighting Outlets, 101-102; Arrangement of, 102; Location of, 102-103
 Light Intensity, Standards of, 102
 Local-Vent Water Closet, 36
 Location for Sewage Disposal Plant, Selecting a, 78
 Location of Air Registers in Classrooms, 10-12
 Location of Disposal Field, 82
 Location of Exhaust Outlet in Toilet Room, 25
 Location of Exhaust Registers, in Lunchroom, 31; Lighting Fixtures, 100; Lighting Outlets, 102-103; Plumbing Fixtures, 43; Swimming Pools, 93
 Locker Rooms, 93
 Low Pressure Heating Plant, 84, 86
 Low Vacuum Cleaning System, 104-105
 Lunchroom, Location of Exhaust Registers, 31; Standard of Air, 31

 Marble Fixtures, 34
 Material and Height of Wainscot in Toilet Room, 48
 Metal Work for Shower Bath Partitions, 52-53
 Mixing Dampers, Air, 13-14
 Motor, Air for Temperature Regulation, 22; Generator Set, 89
 Mushroom Inlets in Auditoriums, 19-22

 Natural Lighting of Classroom, 99
 Number of Plumbing Fixtures, 43-44

 Oil Separator, Free Exhaust and, 86
 Operating Cost of Power Plant, 85; Swimming Pool, 90-91
 Organization of Schoolhouse Construction, 7
 Outlets, Arrangement of Lighting, 102; Floor, 103; Vacuum Cleaning, 105-108; Location of Lighting, 102-103
 Overflows, Pool, 98

 Partitions, Alberene Stone, 48; Argentine Glass, 48; Closet, 48-50; Slate, 48
 Pedestal Fountains, 41
 Percolating Filter System, 78
 Piping, Installing Vacuum Cleaning, 107

 Plumbing, 32
 Plumbing Fixtures, Location of, 43; Number of, 43-44; Selection of, 32-35
 Pneumatic Compression Tank, 36
 Pneumatic Tank, 54
 Pneumatic Water Supply Systems, 54-56; for Fire, 71
 Pool, Cost of Equipped, 98
 Pool Equipment, Arrangement of, 95
 Porcelain Lavatories, 40
 Porcelain Ware, 33
 Power, Electric, 84
 Power Plant, Cost of, 84; Economy of, 84; Operating Cost of, 85
 Pressure Filters, 57
 Pressure, Water, 59-60
 Producer, Vacuum, 104
 Protection, School Fire, 68
 Pump, Centrifugal (Pool), 95; Centrifugal Water, 59; Circulation for Drinking Water, 76; Circulation (Pool), 95; Fire, 71; House, 87

 Rack, Hose, 70
 Radiators, Auditorium, 21
 Range Water Closets, 35
 Reducing Valves, 56-57
 Refrigeration Systems, 74
 Registers, Assembly Halls, 19; Supply and Exhaust, 10-12
 Regulation, Automatic Temperature, 22-24
 Regulator, Damper, 24; Thermostatic Hot Water, 65
 Revolving Damper for Auditorium Ventilation, 21
 Rooms, Locker, 93
 Rules for Operating Swimming Pools, 98

 Sand Filter System, Intermittent, 78
 School Boards, 7
 Scum Gutter, 98
 Selection of Plumbing Fixtures, 32-35
 Selecting a Location for Sewage Disposal Plant, 78
 Semi-indirect Illumination, 100
 Semi-indirect Lighting Fixture, 100
 Semi-transparent Shades, 100
 Separator, Free Exhaust and Oil, 86
 Septic Tanks, 78-81
 Sewage, 78-81
 Sewage Disposal, Contact System, 78
 Sewage Disposal Plant, Selecting a Location, 78
 Shades, Semi-transparent, 100
 Shower Bath and Dressing Room, 50; Compartment, 50-52
 Shower Baths, 93; Metal Work for Partitions, 52-53
 Shower, Gang, 67
 Shower Mixing Valve, 65
 Siamese Outlets, 68-69
 Sinks, Cooking, 42; Kitchen and Slop, 41
 Slate Fixtures, 34; Partitions, 48
 Slop and Kitchen Sinks, 41
 Sprinkler System, Automatic, 68-69
 Standard of Air Change, 9; in Assembly Halls, 19; Lunchroom, 31
 Standards of Light Intensity, 102
 Standpipe System, 68-71
 Steam Heat, 84
 Sterilizers, 57-59; Electric, 97-98; Pool, 91-95; Ultra-violet Ray, 57-59
 Study Room, Ventilation of, 19
 Supply Registers, 10-12; Assembly Halls, 19
 Sweepers, Vacuum Cleaning, 104
 Swimming Pool, Construction of, 93-94; Length of Time Water Can be Retained in, 91-93; Location of, 93; Operating Cost of, 90-91; Pure Water, 90; Rules for Operating, 98; Waterproofing, 94
 Swimming Pools in the United States, Average Conditions of, 93

- Switches, Location of Wall, 103
- Syphon Jet Water Closet, 35
- Tank, Cooling Water, 75; Gravity, 36, 54-57; Gravity Fire, 71; Pneumatic, 54; Pneumatic Compression, 36; Septic, 78-81; Water House, 59
- Temperature, Control of Water, 66
- Temperature Regulation, Air Motor for, 22; Automatic, 23
- Thermostatic Control, 24
- Thermostatic Hot Water Regulator, 65
- Toilet Exhaust Fans, 25; Exhaust Flues, 25
- Toilet, Normal Enclosure, 48
- Toilet Outlets, Installation of, 25
- Toilet Room Fixtures, 28; Arrangement of, 46
- Toilet Rooms, Arrangement of, 46-47; Basement, 44-46
- Toilet Room, Wainscot, 48
- Toilets, Ventilation of, 25-27
- Top-feed Water System, 59
- Traps, 32
- Trunk Line Duct System, 13
- Tungsten Lamps, 99
- Ultra-violet Ray Sterilizer, 57-59
- Unbalanced Air Pressure in Rooms, 25
- Up-feed System of Hot Water Circulation, 61-63
- Up Supply Sytem of Ventilation, 21
- Urinals, 28, 37-40; Ventilation of, 40
- Vacuum Cleaning, 104
- Vacuum Cleaning Machine, Method of Purchasing, 108; Operation of, 104
- Vacuum Cleaning Sweepers, 104
- Vacuum Cleaning System, High, 104-105; Low, 104-105; Cost of, 108
- Vacuum Cleanouts, 105-107
- Vacuum Producer, 104
- Valves, Hose, 70; Shower Mixing, 65; Flush, 36-37, Reducing, 56-57
- Ventilating Toilets, 25-27
- Ventilation, 8; Auditorium, 19; Down and Up Supply Systems, 21; Chemistry Laboratory, 28; Kitchen, 30; Study Room, 19; Toilet Fixtures, 36; Urinals, 40
- Vitreous Lavatories, 40
- Vitreous Ware, 33
- Wainscot in Toilet Room, Material and Heighth of, 48
- Wall Hung Closet, 37
- Wall Hung Fountain, 41
- Wash-down Closet, 35
- Water Cooling Tank, 75
- Water, Drinking, 73; in School Swimming Pools, 90; Methods of Cooling Drinking, 74; Methods of Heating, 62-65
- Water Pressure, 59-60
- Waterproofing, Swimming Pools, 94
- Water Pump, Centrifugal, 59
- Water Supply, 54
- Water Supply System, Pneumatic, 54-56; Fire, 71; Hot, 61
- Water Temperature, Control of, 66
- Well, Artesian, 95

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